Latest Progress in Research on AHE and Circumstantial Nuclear Evidence by Interaction of Nano-Metal and H(D)-Gas

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10 authors, including:

Akito Takahashi
Osaka University

Latest Progress in Research on AHE and Circumstantial Nuclear Evidence by Interaction of Nano-Metal and H(D)-Gas

Akito Takahashi[1,2*], Toyoshi Yokose[3], Yutaka Mori[3], Akira Taniike[3], Yuichi Furuyama[3], Hiroyuki Ido[2], Atsushi Hattori[2], Reiko Seto[2], Atsushi Kamei[2], Joji Hachisuka[2]

[1]Prof. Emeritus Osaka University, [2]Technova Inc., [3]Kobe University

*corresponding author

Abstract Latest results on anomalous heat effect (AHE) by interaction of binary nano-composite metal powders and H (or D) gas, after the NEDO-MHE project (2015-2017), are of subjective in this paper. PNZ10 (Pd_1Ni_{10}/zirconia) and CNZ7 (Cu_1Ni_7/zirconia) powders by melt-spun and calcination method were for AHE active material samples, and were re-used by additional calcination. 80 to 400 W/kg level excess thermal power Wex of sustainable continuity for several weeks have been reproducibly observed at elevated temperature around 300 °C, by using re-calcined PNZ-type samples with D-gas, significantly in net D-gas desorption mode. Specific reaction energy (η-value) per D-transferred was very large as 100 eV/D to over 500 eV/D. Very weak (0.1-0.2 n/J level) neutron emission looked correlating with the rise-up heat hump of thermal power after joule heating started. These results can be of the circumstantial nuclear signature of the AHE by the nano-metal D-gas interaction. Data of 50 to 140 W/kg level excess thermal power was repeatedly obtained by CNZ-type samples with H-gas at elevated temperatures after the saturation of H-gas absorption (endothermic) by sample. Excess thermal power of ca. 50 -70 W continued for more than two weeks by 505 g CNZ7r (re-calcined) sample, with very strange evolution of the "cooled-flat and oscillating" TC4 RC upper flange temperatures. The effect has been investigated, and we concluded as a kind of turbulence gas-flow of up- and down-stream by strong local AHE. Big or small heat bursts were observed many times in the rise-up data after the start of external heating from room temperature. The η-values were obtained to be so large as more than 10,000 eV/H-transfer for CNZ7r sample runs, implying some nuclear effect. Observation of AHE is repeatable by the interaction of H (or D) gas and Ni-based nano-composites metal powders. Reproducibility is established. Condition to realize the apparent equilibrium pressure with maximum dynamic H (or D) gas flux in both direction of desorption and sorption on surface of nano-composite metal particle is considered to be of key factor. Higher temperature than 300 °C for RC with homogeneous gas feed for eliminating the gas turbulence is to be tested.

Key words: anomalous heat, enhancement, Ni-based, nano-composite-metals, hydrogen gas, elevated temperature, 100 W/kg, excess thermal power, repeated calcination, circumstantial nuclear evidence, gas turbulence, specific reaction energy, over 1 keV/H(D)

I. INTRODUCTION

The anomalous heat effect (AHE) by the interaction of hydrogen-isotope-gas and nickel-based nano-composite samples as Pd-Ni/zirconia (PNZ) and Cu-Ni/zirconia (CNZ) powder samples at elevated temperatures around 300 °C has been studied intensively [1,2] under the NEDO-MHE project in 2015-2017 [3], for verifying the existing of the phenomenon and finding conditions of excess power generation in controllable way. As reviewed in ref. [4], the 8 year-long (2008-2015) series of study on AHE by interaction of metal nanoparticles and D(H)-gas under the collaboration of Technova Inc. and Kobe University has become the basis for the collaborative research of NEDO-MHE. The AHE phenomenon has been replicated by independent experiments at Tohoku University as well as at Kobe University under the collaboration study of the NEDO-MHE project [5, 6, 7]. Observed excess thermal power level of AHE were on the level of 3-20 W, and more enhancement for industrial application was expected.

To scale up the AHE power level, study has been extended [8, 9] independently at Kobe University as the collaboration project with Technova Inc., after the 2015-2017 NEDO-MHE project. Big heat burst of ca. 3 kW for about 100 s was observed by the 1 kg Cu_1Ni_7/zirconia sample (CNZ7) with hydrogen gas in the initial heating-up phase, but sustaining excess thermal power around 300 °C temperature of reaction chamber (RC) was small as ca. 14 W/kg for many months [8]. However, as reported in this paper, our succeeding experiments with the re-calcined sample (CNZ7r) has shown about 8 times enhancement of excess thermal power (100-140 W/kg level). Our succeeding experiments with re-calcined PNZ10r (Pd_1Ni_{10}/zirconia) sample with D-gas has also given significant enhancement of excess thermal power (50-120 W/kg level), as shown in this paper. During the scaling-up experiments, we had the new findings of H(D)-gas turbulence effect on the Kobe-Technova C-calorimetry system. Somewhat detail of the H-gas turbulence effect under strong local AHE, which underestimated drastically excess thermal power by coolant-oil out let temperatures and did not affect the calorimetry by the position-averaged RC temperatures, will be reported with discussions in this paper. Typical AHE data for heating rise-up phase of each run, and for several weeks sustaining excess thermal power runs, are shown in this paper for CNZ7, CNZ7r and PNZ10r runs.

We have reported [1-9] repeatedly on the fact that specific reaction energy per H (or D) transferred (or spent) was too large to explain by known chemical reaction energies. In this paper we add newer results of anomalously high specific reaction energy over 1 keV/H(D)-transferred under the AHE phenomenon. In the case of runs by PNZ10r sample with D-gas, time evolution pattern of very weak neutron emission looked correlating with rapid local AHE temperature rise in RC. These observations must be circumstantial evidences of some nuclear reactions for underlying mechanisms of the AHE, as predicted by the condensed cluster fusion theory (CCF/TSC theory) by Akito Takahashi (see many papers downloadable at Research Gate [10]). For an introduction of CCF/TSC theories, the review paper [11] is recommendable.

II. EXPERIMENTAL METHODS AND PROCEDURE

The fabrication procedures of Pd-Ni/zirconia and Cu-Ni/zirconia for nano-composite samples were described in our previous papers [1-9]. The outline is 1) making thin (ca. 10 micron) amorphous ribbons of $Pd_xNi_yZr_z$ or $Cu_xNi_yZr_z$ metal composite aloys by the melt-spun method, 2) calcination in electric oven at ca. 450 °C for 120-180 hours, and 3) making ca. 0.1mm size powders by automatic mortaring machine. The atomic ratios of x/y/z are from 1/10/20 to 1/7/14, approximately. In the present work, we used Pd1/Ni10/Zr20 and Cu1/Ni7/Zr14 for PNZ10 and CNZ7 samples, respectively. After the first H(or D) gas charging and elevating temperature runs (#1-N, N=1,2,3), we took out the sample from RC (reaction chamber) to make re-calcination in electric oven in ambient air with ca. 450 °C for ca. 180 hours. Then we reused for the second H(D)-charging and temperature-elevation runs (#2-N, N=1,2,3).

Between N=1 and 2 or N=2 and 3, we made so called baking treatment with 250-450 °C RC average temperature under vacuum-evacuation to meet the final RC pressure of less than 1 Pa.

To realize the nano-core/incomplete shell structure with 2-10 nm nano-islands in ceramics (zirconia in the present case) supporter flake (several tens micron), atomic ratio of minor outer shell element (Pd or Cu in our case) and inner core (Ni in our case) may have optimum value around Pd (or Cu)/Ni = 1/7 to 1/10. The PNZ10 sample for the present work has Pd/Ni = 1/10. The CNZ 7 sample has Cu/Ni = 1/7. Confirmation of nano-islands has been made by the STEM/EDS analysis, for samples done in previous works [3, 4]. STEM/EDS analysis for used samples in the present work is under way, which is considered to be of key information why the AHE enhancement is caused by the repeated calcination treatment.

The C system schematics for AHE calorimetry at Kobe University has been many times shown [1, 2, 4 -9]. We copied again in Fig.1 for reader's convenience.

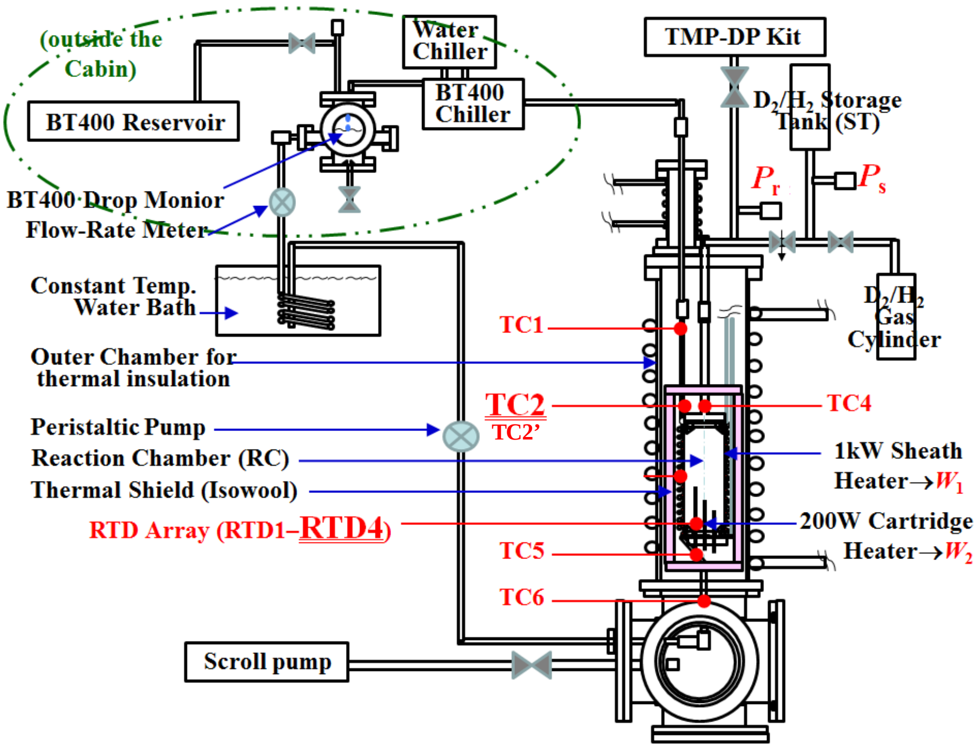

Fig. 1. Schematic of the C system of Kobe U for AHE calorimetry, equipped with oil-flow-calorimeter system with flow-rate-monitors and dual heaters [W1, W2] .

Calorimetry calibration data are given in [8] for TC1-TC6, TC2-TC6, and RTDav-TC6, by using blank sample of 1mm diameter zirconia beads (ca. 1.4 kg), for oil flow rate 18.4 ccm. In order not to make correction for oil-flow rate variation during runs, experimenters have adjusted flow rate for keeping near around 18.4 ccm in needed timing (not frequent). For heating up RC, we used constant power supply units by Keithley Co., so that we did not need any correction for input heater power variation for [W1, W2]= [120, 80] W and [140, 95] W ET (elevated temperature) runs.

H (or D) gas was initially filled in Gas Cylinder (Fig.1) having volume of 4 litters (for H-gas) and 2 litters (for D-gas), and fed to RC through Super Needle Valve (valve with arrow in Fig.1). Initial pressure of Gas Cylinder was 0.4 to 1.0 MPa. By adjusting the SNV path size, we set gas flow rate as it took about 60 min to reach the equilibrium pressures at Ps and Pr, for the case of blank calorimetry runs. When we had the AHE of significant amount, evolution of Pr and Ps were changed significantly from the blank runs. From the variation of Ps and Pr, we could calculate rate of H (or D) gas molars (or number of atoms) transferred by the runs. For present works, H-gas was used for CNZ7 and CNZ7r runs, and D-gas was used for PNZ10r runs. D-gas runs for CNZ-type samples and H-gas runs for PNZ-type samples are yet to be done.

Typical patterns of the AHE experiments are as follows;

0) baking the sample (#1-0, #2-0),
1) H (or D) gas charging to RC at room temperature (RT) (heaters: [0, 0], #1-1, #2-1),
2) elevate RC temperature (heaters: [120, 80], "#1-2, #2-2),
3) cool RC to RT (heaters: [0, 0], #1-3, #2-3),
4) elevate RC temperature (heaters: [140, 95], #1-4, #2-4), and so on.

Actual run-tables are given in Table-1, 2 and 3, respectively for CNZ7, CNZ7r and PNZ10r.

Table-1: Run table of CNZ7 (1137g CNZ7 sample + 439g zirconia beads filler)

Run Number ID	W1, W2 (W)	Gas Fill Ps Pressure	Starting Time	RTD4 max (deg C)	Wex max (W)
#1-1	0, 0	H 0.93 MPa	2018/9/18	96	24
#1-2	120, 80		2018/9/19	470	152
#1-3	95, 60	H 0.46 MPa	2018/9/20	233	0
#1-4	120, 80	H 0.86 MPa	2018/9/21	272	-2
#1-5	0, 0	H 0.83 MPa	2018/9/25	25	0
#1-6	120, 80		2018/9/25	284	10
#1-7	0, 0		2018/9/28	25	0
#1-8	120, 80	H 0.49 MPa	2018/10/1	283	10
#1-9	140, 95	H 0.52 MPa	2018/10/9	320	11
#1-10	120, 80		2018/10/12	281	8.6
#1-11	140, 95		2018/10/15	331	19
#1-12	0, 0		2018/11/7	25	0
#1-13	140, 95		2018/11/12	321	14.6
#2-0	140, 40	baking/evacuation	2018/11/19	253	
#2-1	0, 0	H 0.2 MPa	2018/11/21	26	1
#2-2	120, 80		2018/11/26	281	8
#2-3	140, 95		2018/12/3	321	13.9
#2-4	0, 0		2018/12/21	24.6	0
#2-5	140, 95	H 0.29 MPa	2019/1/9	318	17.9
#3-0	140, 40	baking/evacuation	2019/1/18	256	
#3-1	0, 0	D 0.43 MPa	2019/1/21	26.5	1
#3-2	120, 80		2019/1/21	280	7
#3-3	0, 0		2019/1/28		0
#3-4	140, 95		2019/1/28	319	14
#4-0	140, 40	baking/evacuation	2019/2/4		
#4-1	0, 0	D 0.3 MPa	2019/2/6	25.5	0.7
#4-2	140, 95		2019/2/6	319	14.4

Table 2: Run Table of CNZ7r (505g CNZ7r sample + 863g zirconia beads filler)

Run Number ID	W1, W2 (W)	Gas Fill Ps Pressure	Starting Time	RTD4 max (deg C)	Wex max (W) by RTDav
CNZ7r#1-0	140, 40	Baking under Evac	2019/5/10		
CNZ7r#1-1	0, 0	Ps= 0.468 Mpa H-gas	2019/5/13	29.6	0.7
CNZ7r#1-2	120, 80		2019/5/13	280.5	52
CNZ7r#1-3	140, 95		2019/5/15	319.7	56.5
CNZ7r#1-4	120, 80		2019/6/3	282.6	48.6
CNZ7r#1-4	120, 80	Ps= 0.47 Mpa H-gas	2019/6/5	282.7	48.6
CNZ7r#1-5	0, 0		2019/6/7	25.8	0
CNZ7r#1-6	140, 95		2019/6/10	318.6	57.9
CNZ7r#1-7	[140,85]⇐[140,105]		2019/6/14	320	54.8
CNZ7r#1-8	0, 0		2019/6/14	26	0
CNZ7r#1-9	140, 95		2019/6/17	317	56
CNZ7r#1-10	0, 0		2019/6/18		
CNZ7r#1-11	140, 95		2019/6/19	319	57.3
CNZ7r#1-12	120, 80		2019/6/20	282	50
CNZ7r#1-13	[140,80]⇐[100,80]		2019/6/21	292	49
CNZ7r#1-14	0, 0		2019/6/21	27	0
CNZ7r#1-15	120, 80		2019/6/24	281.5	52
CNZ7r#2-0	140, 40	Baking under Evac	2019/6/26		
CNZ7r#2-1	0, 0	H-gas feed Ps=0.46 MPa	2019/6/28		
CNZ7r#2-2	140, 95		2019/7/1	323	70
CNZ7r#2-3	0, 0		2019/7/5	27	0
CNZ7r#2-4	120, 80		2019/7/8	283	61
CNZ7r#3-0	140, 40	Baking under Evac	2019/7/10		
CNZ7r#3-1	0, 0	H-gas 0.44 MPa	2019/7/17	26.5	0.1
CNZ7r#3-2	140, 90		2019/7/17	321	69.2
CNZ7r#3-3	0. 0		2019/7/19	27	0

Table-3: Run table of PNZ10r (450g PNZ10r sample + 680g zirconia filler)

Run Number ID	W1, W2 (W)	Gas Fill Ps Pressure	Starting Time	RTD4 max (deg C)	Wex max (W)
#1-0	140, 40	Baking	2019 2 27		
#1-1	0, 0	D gas Ps = 0.96 MPa	2019 3 1	69	15
#1-2	120, 80		2019 3 4	293	35
#1-3	0, 0		2019 3 8	26	0
#1-4	140, 95		2019 3 13	318	33
#1-4	140, 95	D gas Ps = 0.366 Mpa	2019 3 20	323.8	14.4
#2-0	140, 40	Baking	2019 3 27		
#2-1	0, 0	D MPa gas Ps=0.363 MPa	2019 4 1	54	4.2
#2-2	140, 95		2019 4 3	318.8	33.5
#2-3	0, 0	D IW gas Ps=0.951 Mpa	2019 4 10	31.7	3.3
#2-4	140, 95		2019 4 10	320.7	24
#3-0	140, 40	Baking	2019 4 15		
#3-1	0, 0	D gas Ps=0.373 Mpa	2019 4 17	56.9	4.2
#3-2	140, 95		2019 4 19	318.9	31

94

3. RESULTS AND DISCUSSIONS

3.1 H(D)-Gas Turbulence Effect by Local Large AHE

We first time observed a big heat burst of 152 W, estimated by flow calorimetry by the #1-2 run of CNZ7 (see Table-1). At the burst, temperature of coolant-oil out-let points (TC1 and TC2 in Fig.1) reached peak in about 2 minutes. Considering very slow time constant of flow calorimetry (about 60 min, measured by the blank run with dummy zirconia), it was estimated by impulse response function for the calorimetry system that the real exothermic reaction power happened in about 100 s with ca. 3kW peak [8]. We have feared possible explosion accidents in further runs, and decided to decrease amount of sample to be half (ca. 0.5 kg) from the next experiment CNZ7r.

We have tried many runs with CNZ7 sample (ca. 1 kg), by changing heating conditions and H-gas initial pressure (see Table-1). We have not observed similar heat bursts in later runs than #1-2, and long sustaining excess thermal power level was rather small as 10-20 W levels. Typical data of sustaining excess thermal power by the CNZ7 ET (elevated temperature) runs are shown in Fig.2.

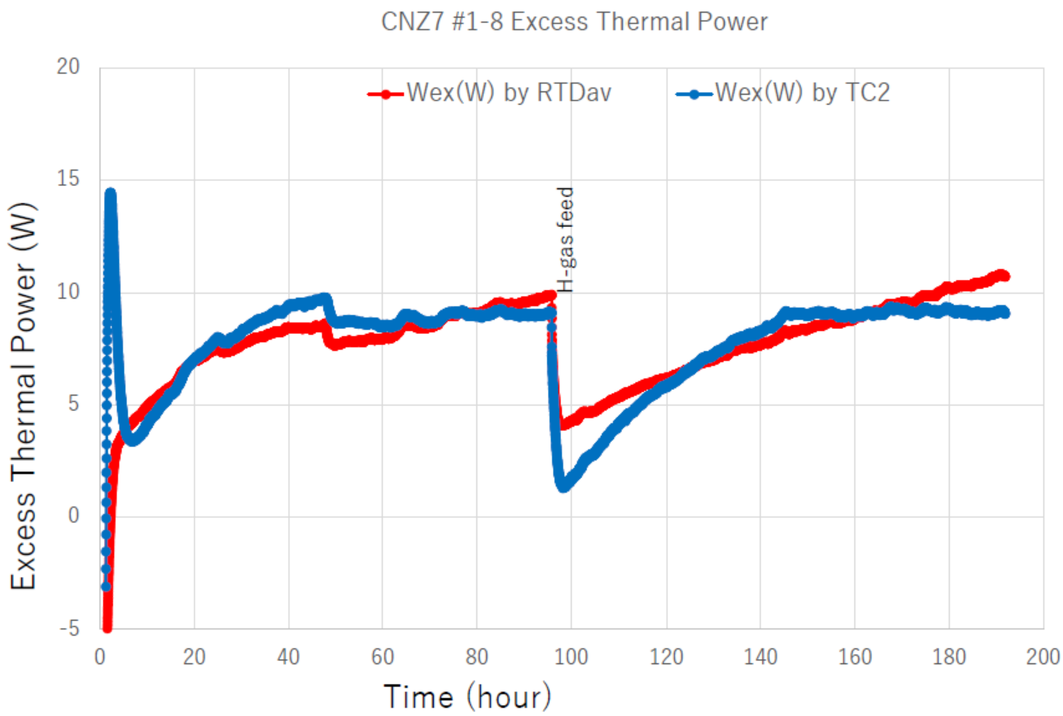

Fig.2: Typical time-evolution of sustaining excess thermal power by CNZ7 ET runs

We see good agreement in calorimetry between one by oil-mass flow method (TC2 in Figure) and the other by average RC temperature method (RTDav), except for the initial rise-up responses due to slower response by the oil mass flow method than that of the RTD response. In this case, time evolution data of temperatures at interested points (TC4, TC2 and RTDav) behaved very similarly (see Fig.3). This kind of state in calorimetry can be regarded as “normal”. However, when there happens large local anomalous heat effect (AHE), we have met observation of very strange behavior of TC4 (gas inlet/outlet point of RC upper flange) temperature evolution, which underestimated significantly oil-outlet temperatures (TC1 and TC2), as we explain in the following.

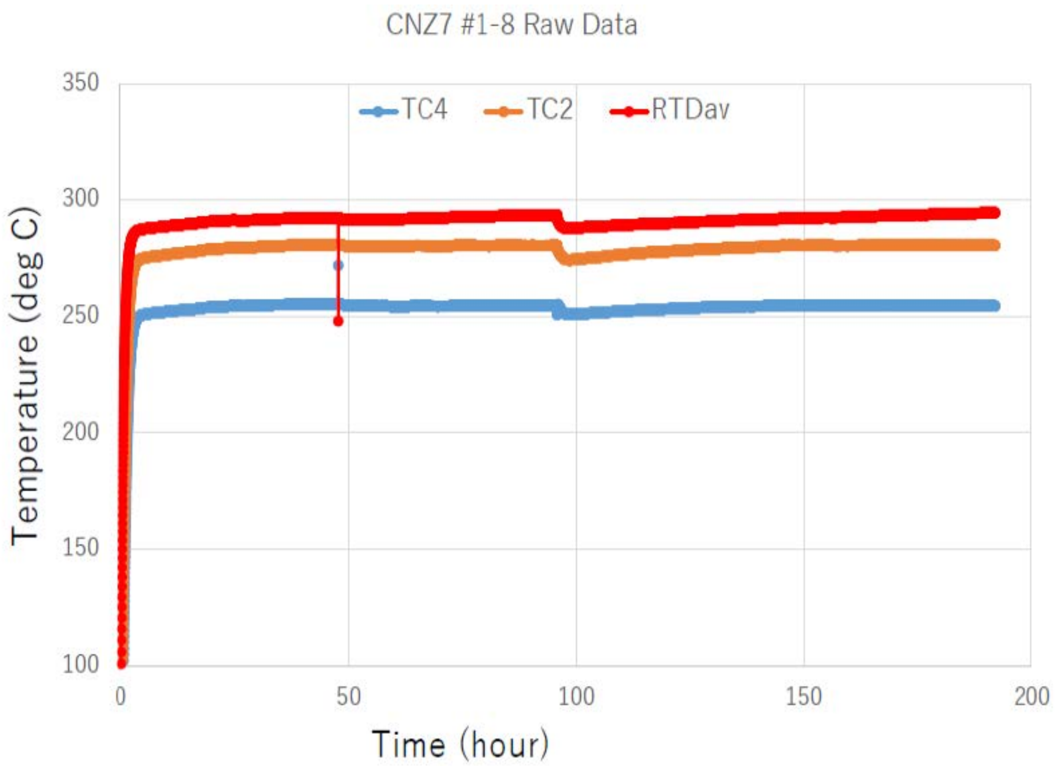

Fig.3: Temperature evolution data of CNZ7 #1-8 run for TC4, TC2 and RTDav, where data for a minute are missing before time 50 hours.

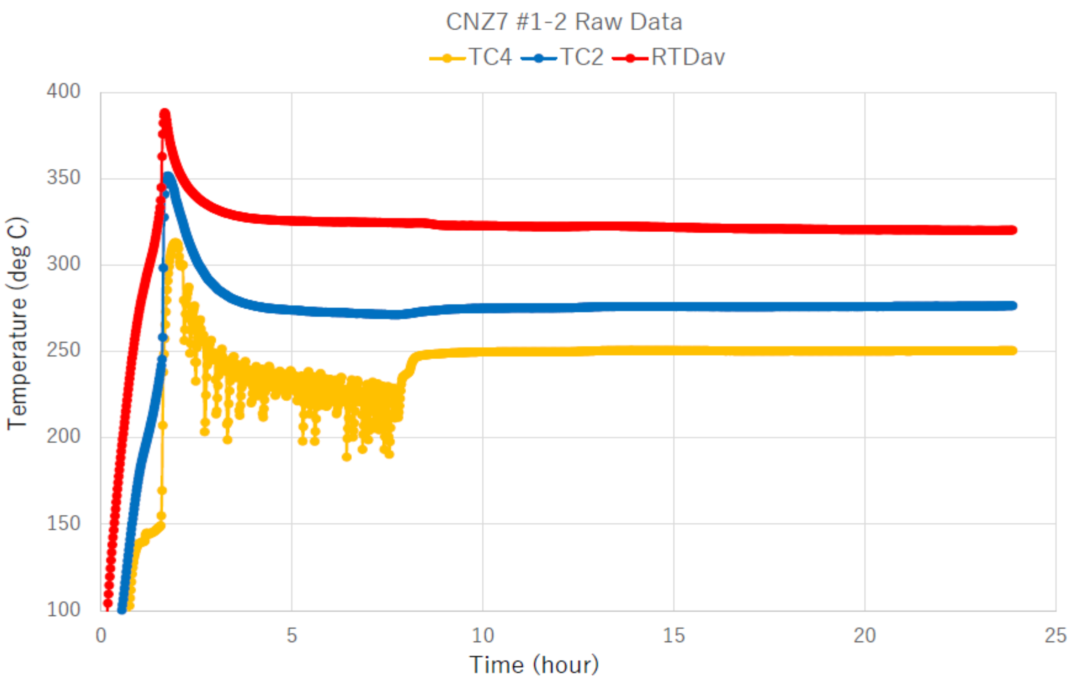

Fig.4: Temperature evolution data for the CNZ7 #1-2 burst event

In Fig.4, we show temperature evolution data for the #1-2 burst event. Obviously, the behavior of TC4 is very strange with many oscillatory down-spikes. In our previous paper [8], we made speculation that the TC4 flat-and oscillatory evolution was due to transient local balance in endothermic H-absorption and desorption. However, it was wrong. From our succeeding experiments with CNZ7r and PNZ10r of re-calcined samples, we have reached the confirmation of "strong H(D)-gas turbulence effect" under locally strong AHE occurrence, which made drastic underestimation of excess thermal power by using data at TC1 and TC2, due to causing strong distortion of temperature distribution of the C-system. We have also confirmed that the calorimetry by average RC temperature with RTDav was most reliable in all cases, unless the gas pressure of RC is larger than 0.1 MPa. In Fig.5, we show excess thermal power data for the burst event.

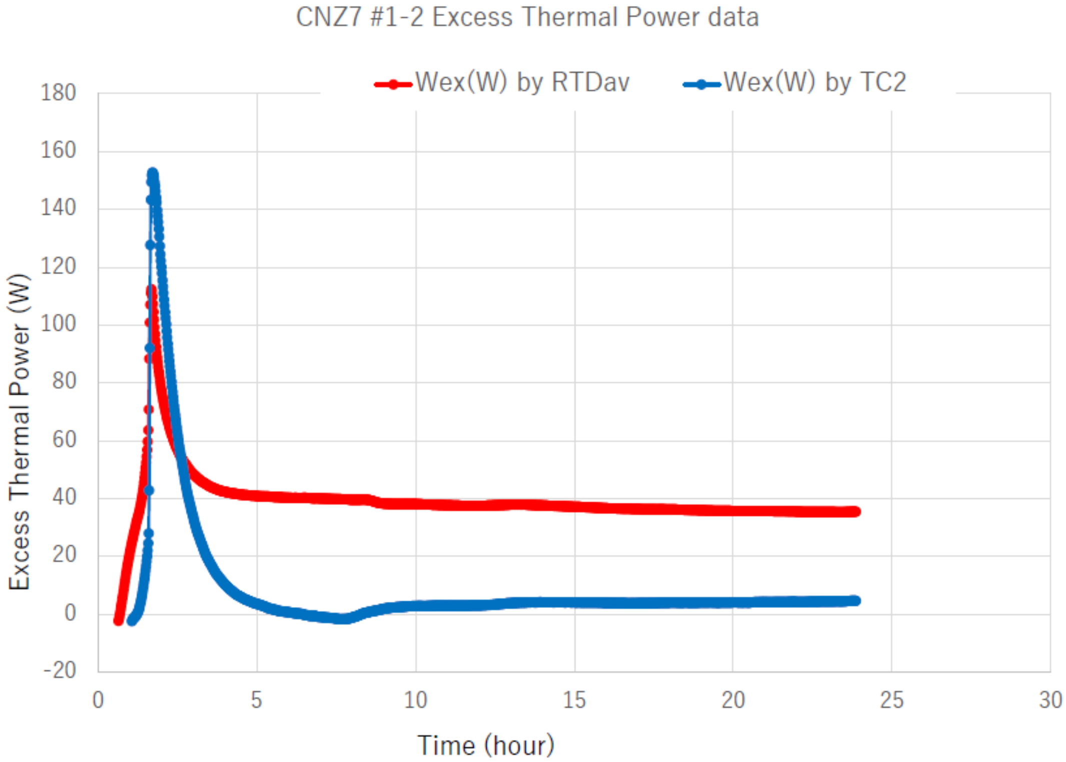

Fig.5: Data for excess thermal power for the CNZ7 #1-2 burst event

At the burst peak, we did not see the H-gas turbulence effect though the peak data by RTDav is smaller than that by TC2. Sensors RTD1,2,3,4 are positioned at 3 cm, 6 cm, 9 cm and 12 cm from the bottom of RC (20 cm high in inner volume). The 1 kg CNZ7 sampler with zirconia beads filler in this run filled fully RC volume. Therefore, Data by RTDav did not contain temperature information in RC upper region, and RTD4 data showed highest value 470 °C to imply higher temperatures at higher points than 12 cm.

As we explain in the following, excess thermal power data by RTDav after the peak are reliable and the data by TC2 should be drastic underestimation due to the H-gas turbulence, which decreased the upper flange temperature as observed by TC4 and disturbed TC2 and TC1 temperatures to be downward. Consequently, we have confirmed that ca. 40 W excess thermal power remained after the burst for a day.

In Fig.6, we show rise-up data by CNZ7r #3-4.

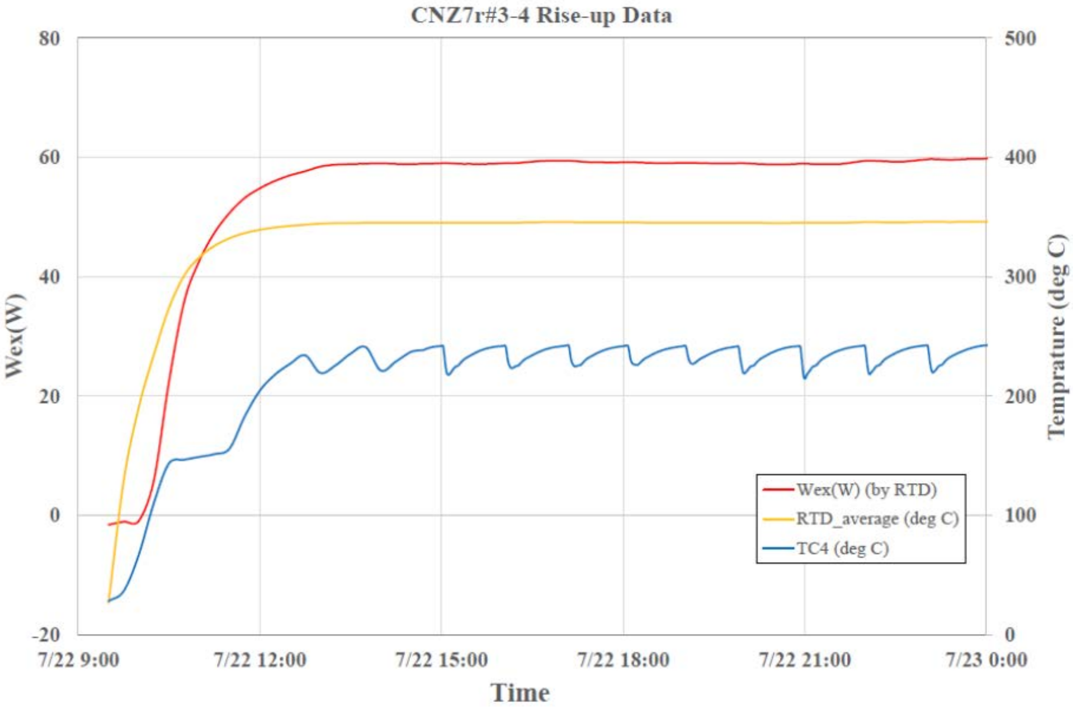

Fig.6: Typical rise-up data for 505g CNZ7r ET runs, example for CNZ7r #3-4, [120, 80], the last run of CNZ7r (not listed in Table-2)

The whole data for a week of CNZ7r #3-4 with [120, 80] heater power input is shown in Fig.7.

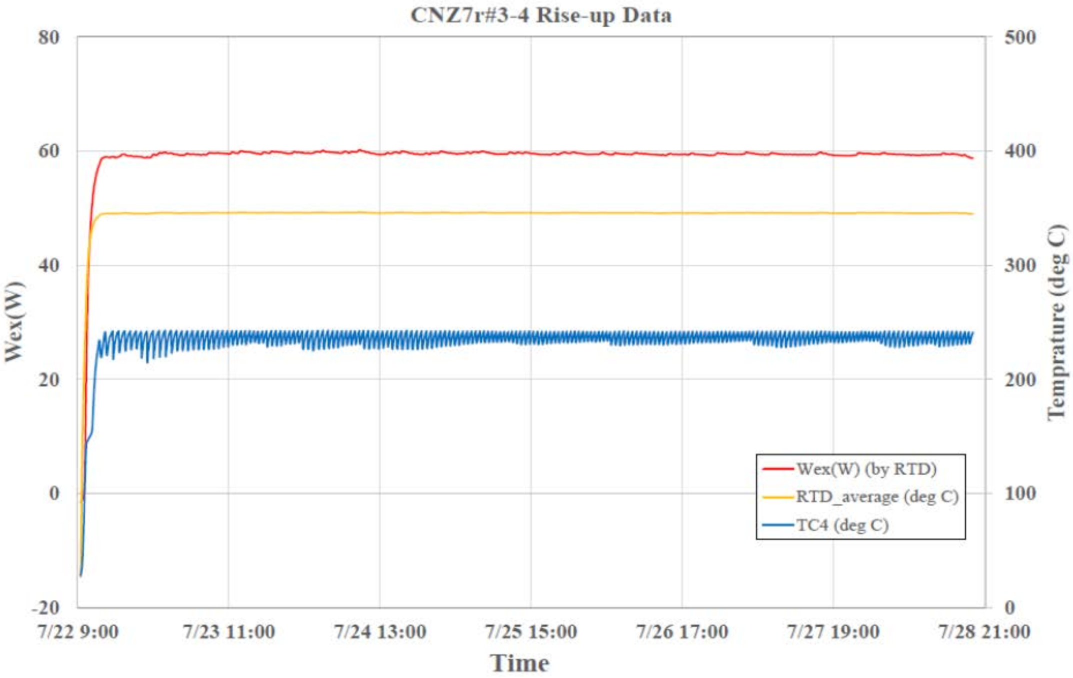

Fig.7: The whole data of one week run for CNZ7r #3-4 [120, 80] with H-gas

Obviously, quite similar behavior of TC4 temperature evolution as to that on CNZ7 #1-2 ET run is seen. The oscillatory TC4 fluctuation looks chaotic as you see in Fig.7. This is regarded as an indication of strong local AHE, which makes H-gas turbulence by generation of chaotic up- and down-stream-paths of convection gas flow in RC.

We have seen many cases of such phenomenon in CNZ7r and PNZ10r ET runs. Some detail of on-going data on the NI (National Instruments)-Lab-View display are given in our slide presentation at ICCF22 [12]. We only show one example in Fig.8.

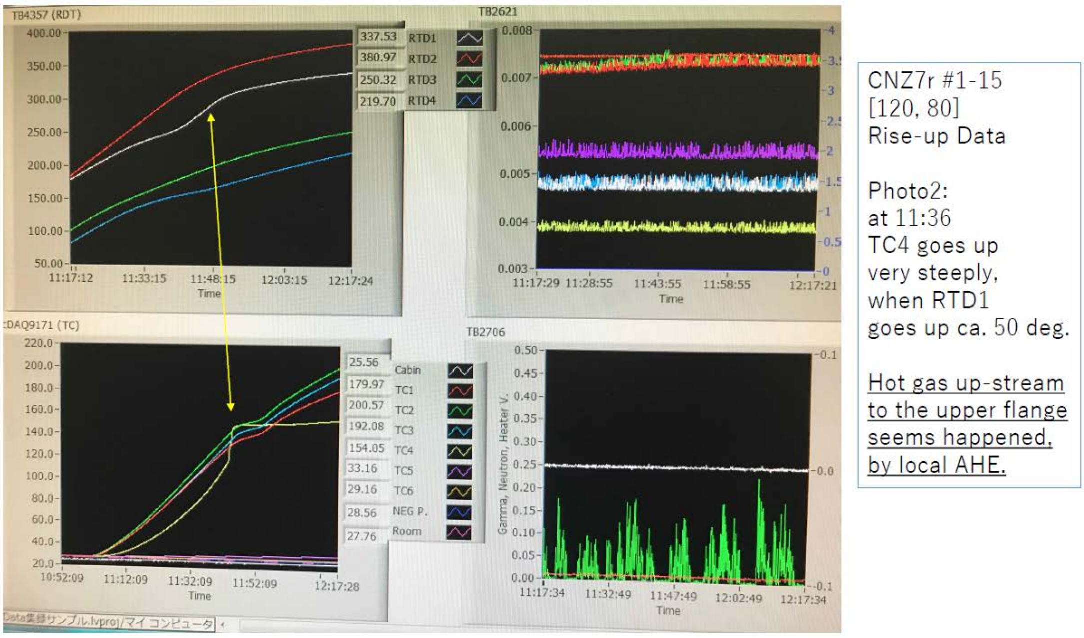

Fig.8: Typical view for the H-gas turbulence effect on rise-up data of CNZ7r ET run

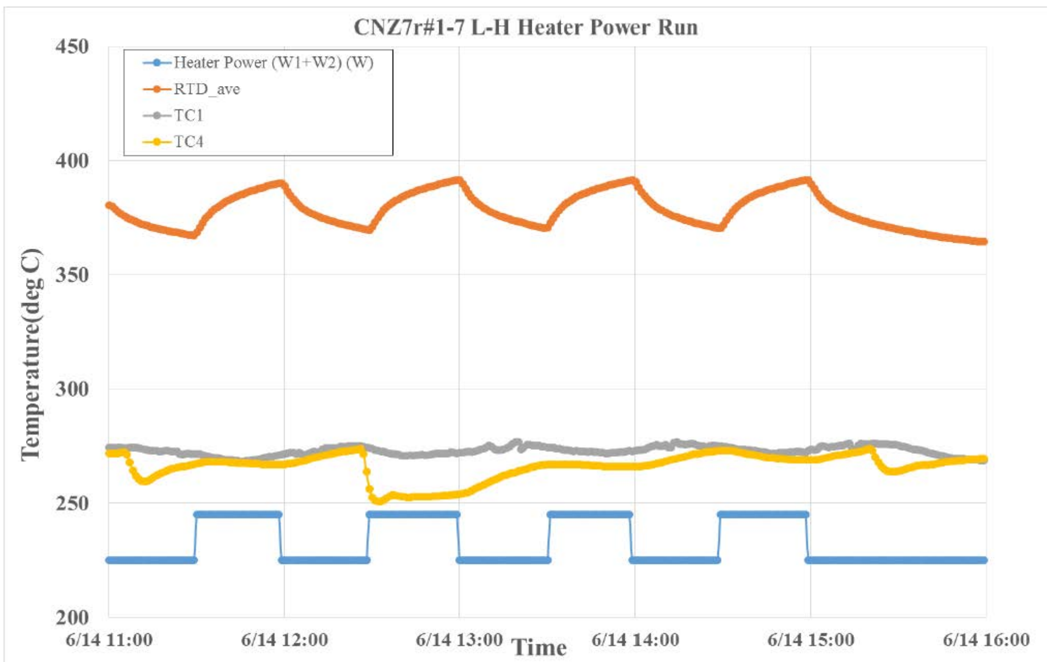

Fig.9: The Low-High heating data under local AHE, from CNZ7r #1-7 run

We can see that the flat cooled temperature evolution at TC4 decreased temperatures at TC1, TC2 and TC3 (see lower left photo). Many more data are available in [12].

To investigate the effect of H-gas turbulence on calorimetry, we have done the low-high heating operation as shown in Fig.9. Clearly, the evolution of TC4 is too strange to regard "normal", and accordingly the oil-outlet temperature TC1 is negatively distorted when heater power increased. Fortunately, evolution of average RC temperature estimated by RTDav looks normally behaving. Consequently, we can employ the calorimetry by RTDav to be reliable measure in all the time.

3-2 Typical AHE Excess Thermal Power Data

We show now typical excess thermal power data for CNZ7r and PNZ10r ET runs. Many data are given in [12]. We only show few typical data here.

In Figs. 10 and 11, we show excess thermal power data for CNZ7r ET runs.

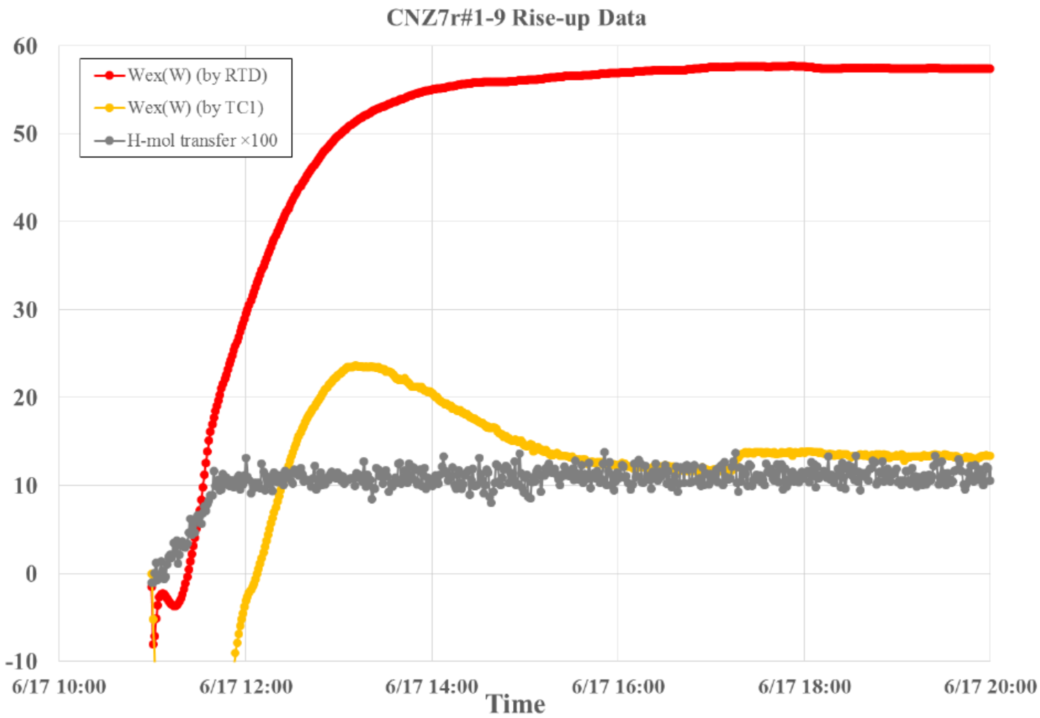

Fig.10: Excess thermal power data and H-gas transferred data for CNZ7r #1-9 run

As already discussed, heat power calorimetry by TC1 is in drastic underestimation in this case, due to the H-gas turbulence effect under AHE, and the excess power by RTDav is reliable. Excess thermal power reached ca. 57 W and continued several days until when we changed the heating condition. The net sample weight of CNZ7r is 505g, so that the relative power level is ca. 113 W/kg. The excess power level increased by the re-calcination (from CNZ7 to CNZ7r) by about 8-10 times. It is a drastic positive effect on the AHE enhancement purpose. An interesting point inferring the mechanism is the fact that AHE is taking place after the desorption of H-gas saturated and with small fluctuation of H-gas sorption/desorption balance (see gray plots).

In Fig.11, we show another typical data for rise-up ET run just after the baking treatment, for CNZ7r #2-2.

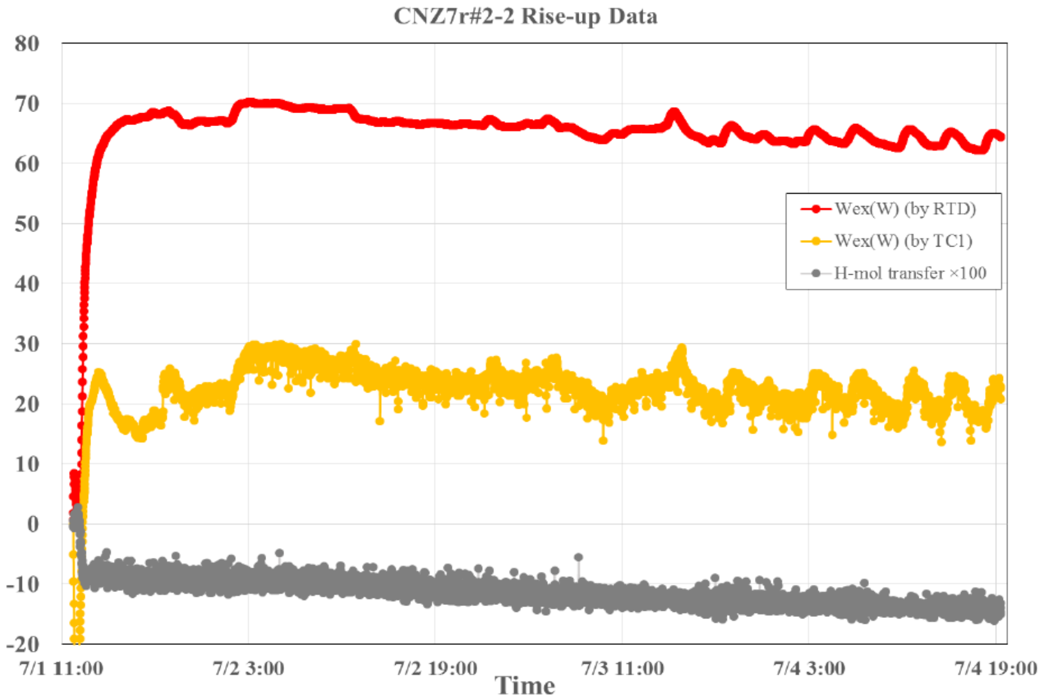

Fig.11: Excess thermal power data and H-gas absorption rate, for CNZ7r #2-2

Evidently, excess thermal power was enhanced about 20 % (to ca. 70-65 W) by the baking treatment. Relative power level is ca. 130 W/kg. AHE happened after the initial rapid H-absorption (endothermic, we know) and during slow H-absorption mode in this case with small gas in/out fluctuation.

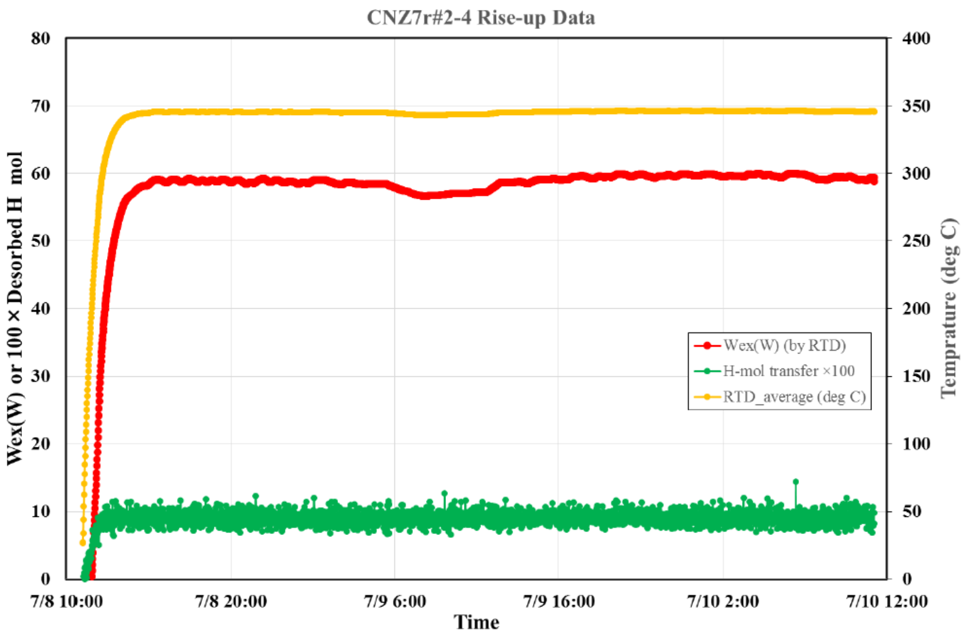

Fig.12: Rise-up data of excess thermal power, average RC temperature and H-gas transferred for CNZ7r #2-4 [120, 80] ET run.

Succeeding run after cooling RC to room temperature showed repeatable generation of AHE as seen in Fig.12. However, AHE in this case took place after the H-gas desorption rate saturated. From these results by Figs. 10-12, we can confirm that heat generation reaction consumed only very small amount of H-gas and happened in delicate balance of H-gas in and out on/through nano-composite islands surfaces of CNZ sample [11]. We have found that H-gas pressure in RC looked optimum for 0.1 to 0.5 MPa.

In Figs.13-15, we show typical AHE data for PNZ10r with D (deuterium)-gas.

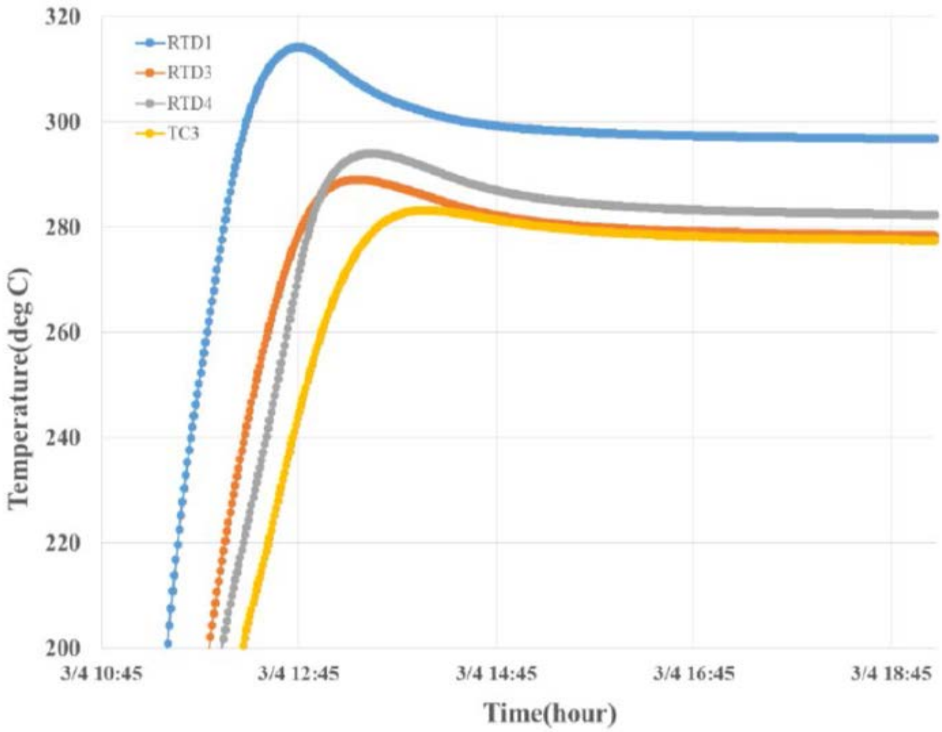

Fig.13: Temperature rise-up data for PNZ10r #1-2 [120, 80] ET run

As seen in Fig.13, the first ET run by PNZ10r #1-2 had heat hump at rise-up evolution. Small amount (Pd/Ni =1/10) of Pd on possible Ni nano-core of islands [11] may have strong catalytic effect [9] to absorb much deuterium (or hydrogen) at #1-1 RT run (1.5 D-mol absorbed). By heating up of #1-2 run, absorbed D-atoms looked desorbed partially first and reached at Ps and Pr pressure equilibrium. Under the slowly going desorption condition, AHE excess thermal power appeared as shown in Fig.14. Corresponding to humps of RTD1,2,3,4 and TC3 temperatures, excess thermal power had small heat burst of ca. 35 W peak and decreased to ca. 15 W (by RTDav) of sustaining level for several days. It happened during the D-desorption mode, and we do not have good reason to explain large exothermal energy generation under the D-gas desorption, in the chemistry sense. This fact may imply that heat source may be nuclear origin.

After the second baking of sample (PNZ10r #2-0 run), D-gas absorption was small (0.37 D mol absorbed) at RT run. In Fig.15, we show excess thermal power and D-desorption rate for PNZ10r #2-2 ET run. The excess thermal power level of sustaining evolution increased to ca. 30 W, which is double score of those of PNZ10r #1-2. The baking treatment is confirmed again to be effective for PNZ10r sample also.

As reported in [9], excess thermal power by ET runs of PNZ10 was so small as ca. 5 W. We can say that the re-calcination treatment could enhance AHE by 3-6 times, as seen by data of PNZ10r.

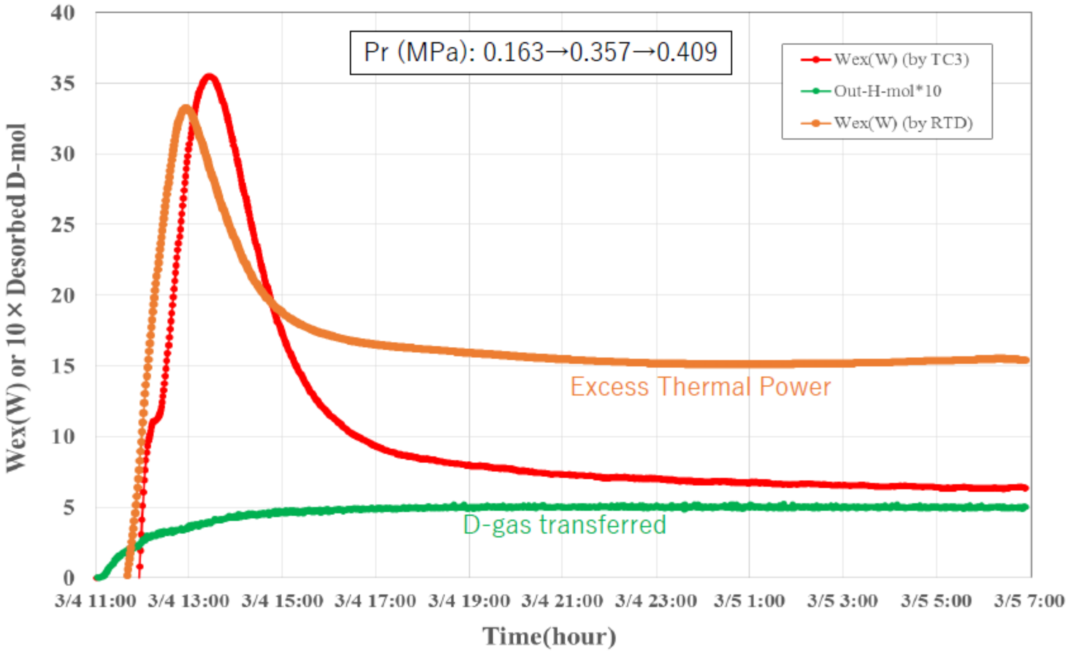

Fig.14: Excess thermal power and D-desorption rate for PNZ10r #1-2 ET run

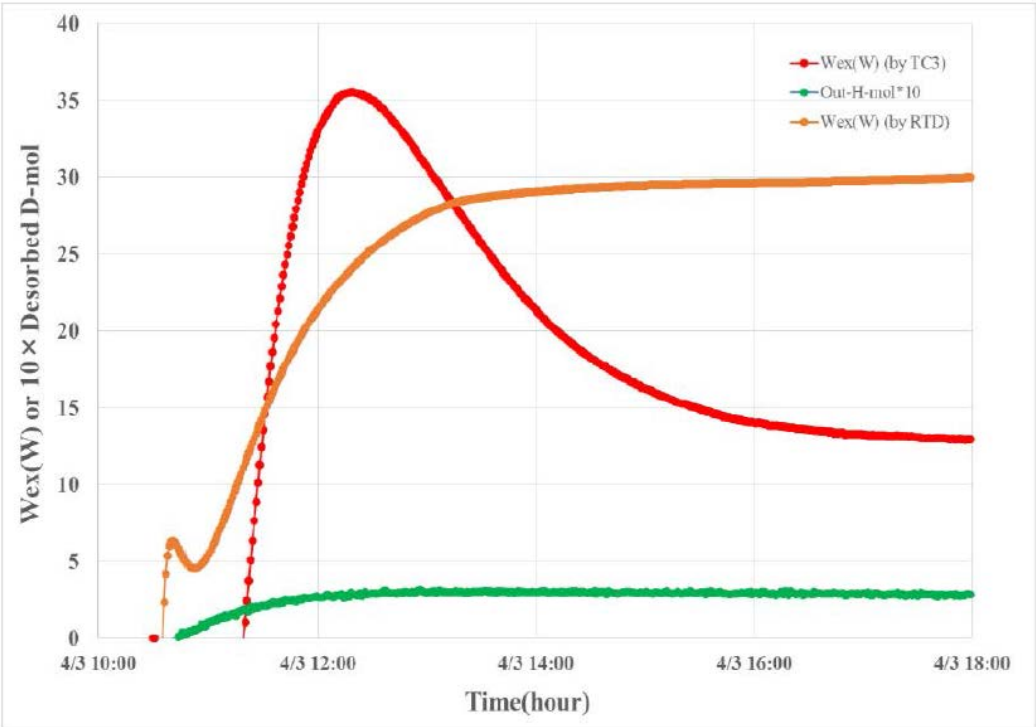

Fig.15: Excess thermal power and D-desorption rate for PNZ10r #2-2 [140, 95] ET run

For summarizing the effect of re-calcination and baking, please see Table-4 and Table-5. From these tables, we can say that the present sample treatments by re-calcination and baking are very useful to enhance the excess thermal power per sample weight. We are looking forward to seeing the results by the third re-calcination to make CNZ7rr and PNZ10rr.

Table-4: Summary of enhancement effect of excess thermal power by re-calcination and baking for CNZ7 and CNZ7r

Run ID; nominal	Heater Input [W1, W2] W	Wex (W/kg): CNZ7	Wex (W/kg): CNZ7r	RC Temp. (°C): CNZ7	RC Temp. (°C): CNZ7r
#1-2	120, 80	(152; burst)	96	(382)	336
#1-4	140, 95	12	110	366	384
#2-2	120, 80	7	118	295	346
#2-4	140, 95	14	126	358	392
#3-2	120, 80	9	115	298	345
#3-4	140, 95	13	137	349	393
Sample (g)		1,150	450		

Tasble-5: Summary of enhancement effect of excess thermal power by re-calcination and baking for PNZ10 and PNZ10r

Run ID; nominal	Heater Input [W1, W2] W	Wex (W/kg): PNZ10	Wex (W/kg): PNZ10r	RC Temp. (°C): PNZ10	RC Temp. (°C): PNZ10r
#1-2	120, 80	5	47	280	301
#1-4	140, 95	4	95	310	366
#2-2	120, 80	10		306	
#2-4	140, 95	14	77	342	357
#3-2	120, 80	8		298	
#3-4	140, 95	18	124	348	379
Sample (g)		965	450		

3.3 Circumstantial Nuclear Evidence by AHE

During all experimental runs, we have monitored radiation levels of neutron (by He-3 counter dose meter) and gamma-spectrum (by NaI scintillator), comparing to those of natural backgrounds. No meaningful counting increase or unknown spectral peaks have ever been observed by the NaI spectroscopy. Natural background of gamma-rays are more than 100 times higher than that of neutrons. Therefore, to detect some increase of gamma-rays by AHE-origin nuclear events, which can be modelled as primary-radiation-free reactions and secondary very weak radiations [11], is very difficult unless the AHE power level would increase in MW level or so. Instead, weak neutron emission might be detected with lower AHE power conditions.

The AHE experiments with PNZ sample and deuterium (D) gas might provide visible neutron emission even with not so large excess power conditions. Example of such case are shown in Fig.16 and 17 for PNZ10r #1-2 run at rise-up heat hump.

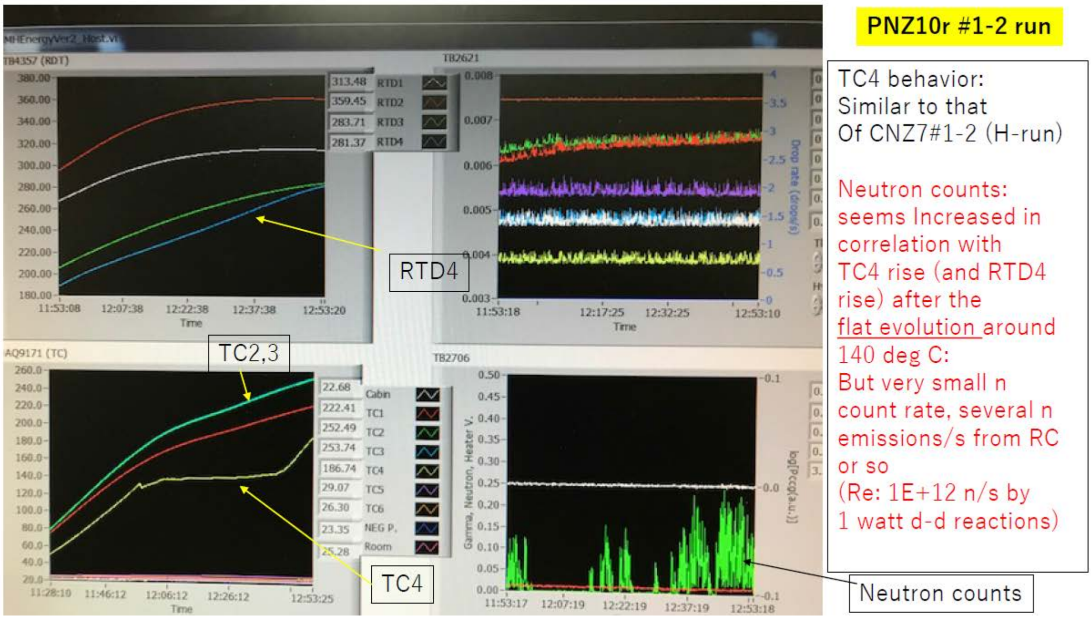

Fig.16: Case of heat-neutron correlation by PNZ10r #1-2 rise-up evolution-1

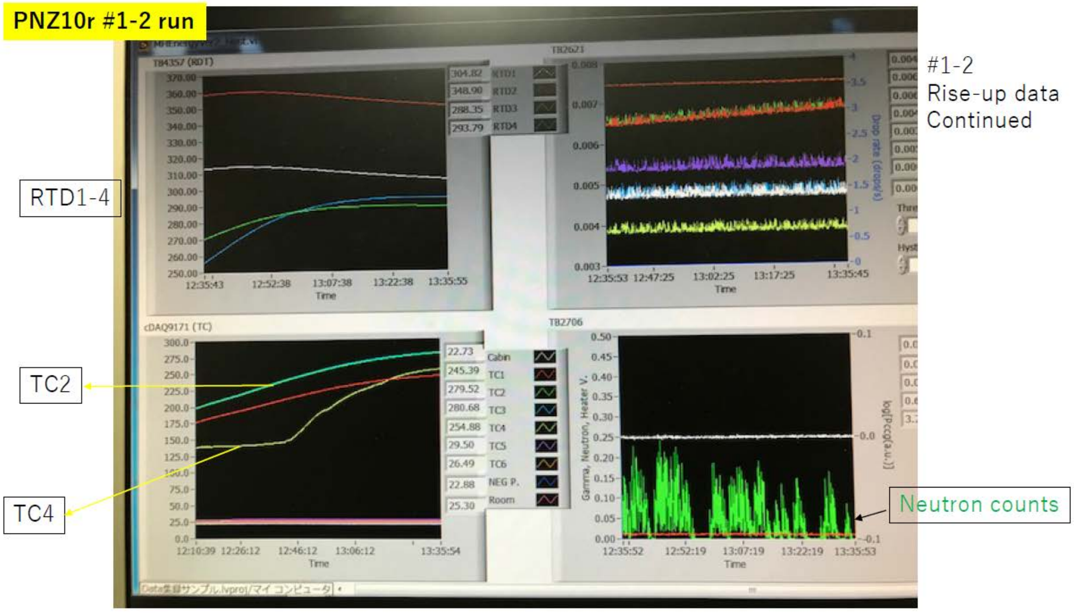

Fig.17: Case of heat-neutron correlation by PNZ10r #1-2 rise-up evolution-2

When RC local temperature RTD4 increased, corresponding to the increase of TC4 temperature escaping from the flat evolution (by D-gas turbulence), neutron counts looks increasing (Fig.16), and later RC temperatures are decreasing in correlation with the decrement of neutron counts (Fig.17). Since the response of neutron detection is very fast (in less than 1 ms), thermal power response by RTDs and TCs of RC are too slow (30 to 60 min time constant) to pick up possible nuclear reaction bursts. Namely, shapes of neutron count rates might show true timing of excess heat origin. During sustaining excess thermal power modes for weeks, weak increase of neutron counts looked sporadic events, which might tell us that AHE nuclear events do not taking place continuously, but do intermittently. Level of neutron yield was 0.1 n/J, which is on the order of 1.0E-13 of that by supposed d-d reactions.

Another circumstantial evidence of nuclear like signature is coming from specific reaction energy data (η -value) per H(D)-transfer. In Fig.18, we show observed evolution of specific reaction energy per H-transfer by CNZ7r sample for one month long series of runs.

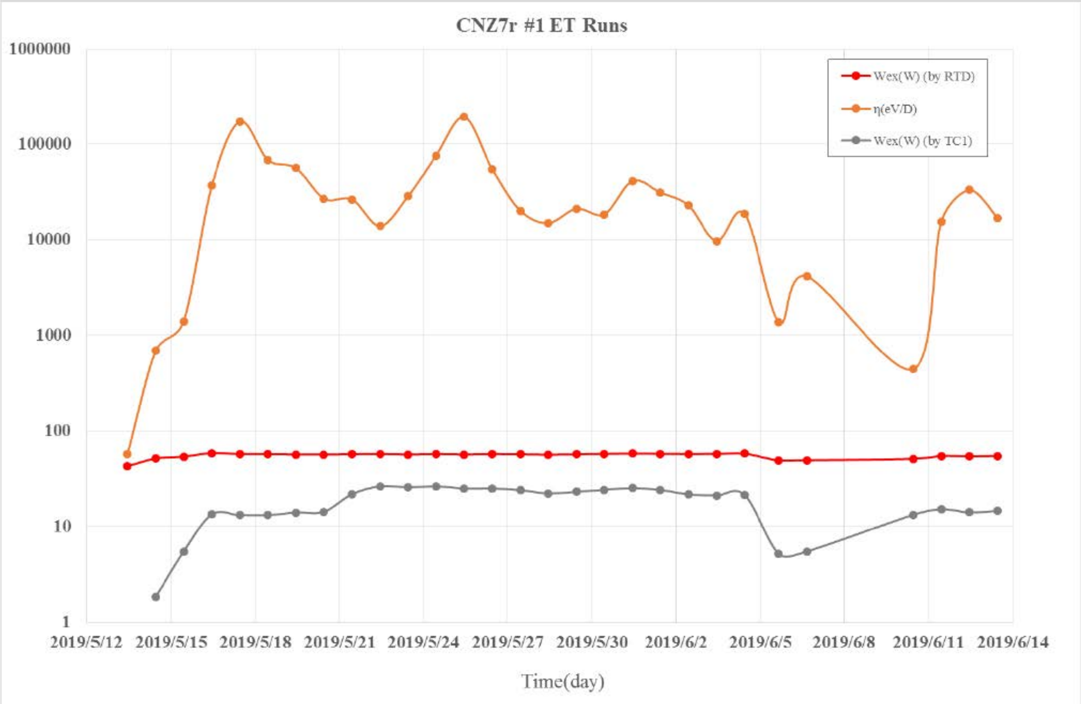

Fig.18: Evolution data of specific reaction energy (brown) by AHE for CNZ7r ET runs

Total heat observed is 128 MJ for 27 days with ca. 55 W excess thermal power level sustaining condition. Corresponding specific reaction energy per H-transfer is mostly more than 10 keV/H, and sometimes took over 0.1 MeV/H, which is very close to nuclear reaction energy level. Considering that not all transferred Hs were spent by AHE reactions, real reaction energy may be more than 0.1 MeV.

In the case of specific reaction energy observation for PNZ10r runs, we had very small gas leakage from RC, unfortunately. Probably, because of the leakage, obtained specific energy data may have been underestimated. We show the results in Fig.19. Level of reaction energy per D-transfer is from ca. 100 eV/D to 500 eV/D. Of course, such data are still beyond explanation by some chemical reactions that are of level in 1 eV/D or less.

We can recall our previous data by PNZ6rr as shown in Fig.20. Largest η- values are close to 1,000 keV/D (namely 1 MeV/D) that is really of "nuclear reaction" signature. Significant high local excess power level as 55 W was observed in central zone of RC (see Fig.20), though total heat recovery data by oil flow showed near 10 W level [9]. As we have explained already in this paper, the D-gas turbulence effect made drastic underestimation of excess thermal power by TC2 and we understand that it should have happened also in the PNZ6rr runs [9]. We can re-evaluate the data of Fig.20 now to conclude that ca. 55 W excess thermal power by Fig.20 is reliable and real. We used ca. 120g sample for PNZ6rr. Relative excess thermal power was ca. 460 W/kg.

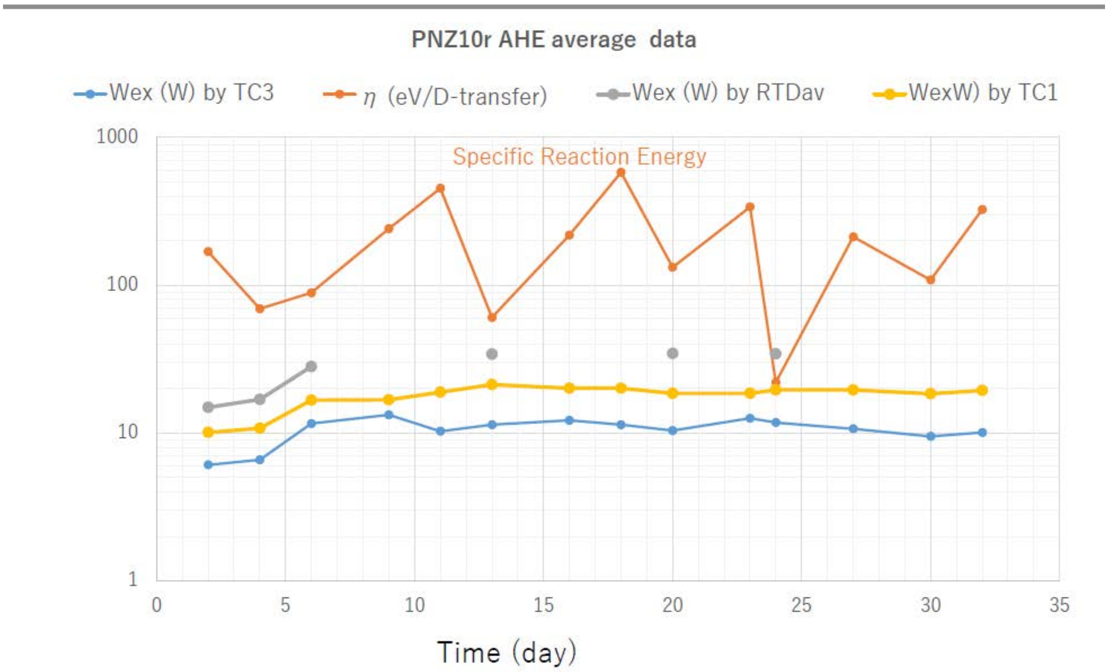

Fig.19: Specific reaction energy data by PNZ10r ET runs

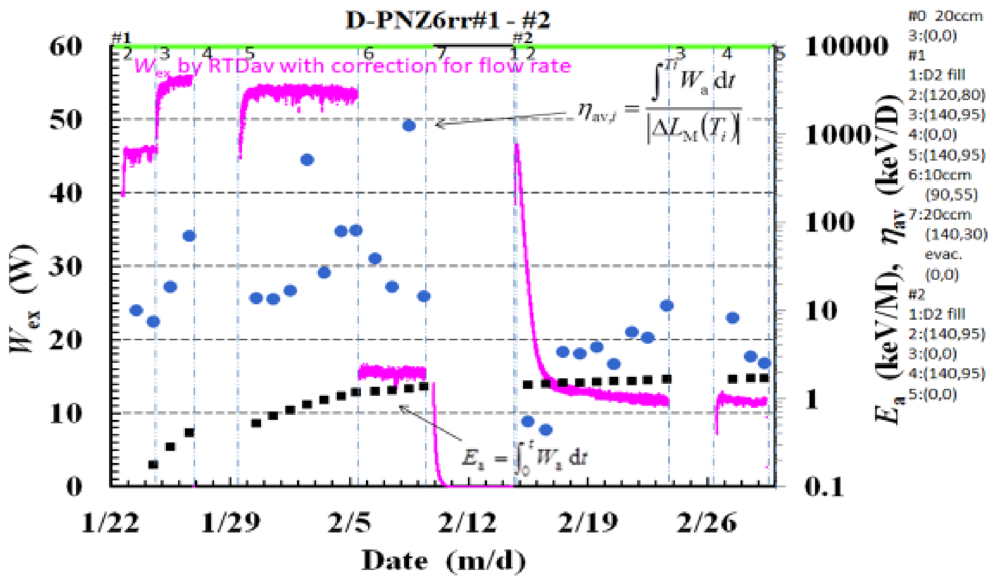

FIG. 20 Processed data of excess thermal power (pink graph), integrated heat energy per M (black square) and eta-value (sky blue circle) for PNZ6rr ET runs around 300 °C RC temperature, obtained by RTD-average data, after [9]

VI SUMMARY AND CONCLUDING REMARKS

As new findings, the H(D)-gas turbulence effect in reaction chamber (RC) under strong AHE power becomes strong in our C-calorimetry system, when we have met strong local AHE power evolution in RC. This gas turbulence effect cooled the RC upper flange and generated chaotic temperature evolution of TC4 upper flange temperature and mostly decreased oil-outlet temperatures monitored at TC1 and TC2. Fortunately, calorimetry by average RC temperature (RTDav) is not distorted visibly and we can rely it as measure of real excess thermal power for all the time.

The re-calcination treatment of CNZ7 and PNZ10 powders is effective to enhance excess thermal power by nearly one order of magnitude. And the baking treatment between ET runs is also effective to enhance AHE.

We got useful knowhow for fabricating sample powders as initial calcination conditions, mortaring process and re-calcination. We may expect more enhancement of AHE power by the second re-calcination to make CNZ7rr and PNZ10rr powders.

Now we can say that reproducibility of AHE generation with 100-400 W/kg excess thermal power level is established by the present nano-composite metal and H (or D)-gas interaction method. Simply, we call it MHE (Metal Hydrogen Energy) as the primary energy generation method.

Origin of AHE can be regarded as some nuclear origin as suggested/modeled by [11]. We have obtained concrete results of circumstantial evidence of nuclear-like signatures in the present work.

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