Anomalous Heat Generation Experiments Using Metal Nanocomposites and Hydrogen Isotope Gas

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- 2. Experimental
- 3. Experimental Results at Tohoku Univ.

  (PNZ4s,CNZ5s, PSn1, CNS3s, CNZ6s)
- 4. Concluding Remarks

1. Background

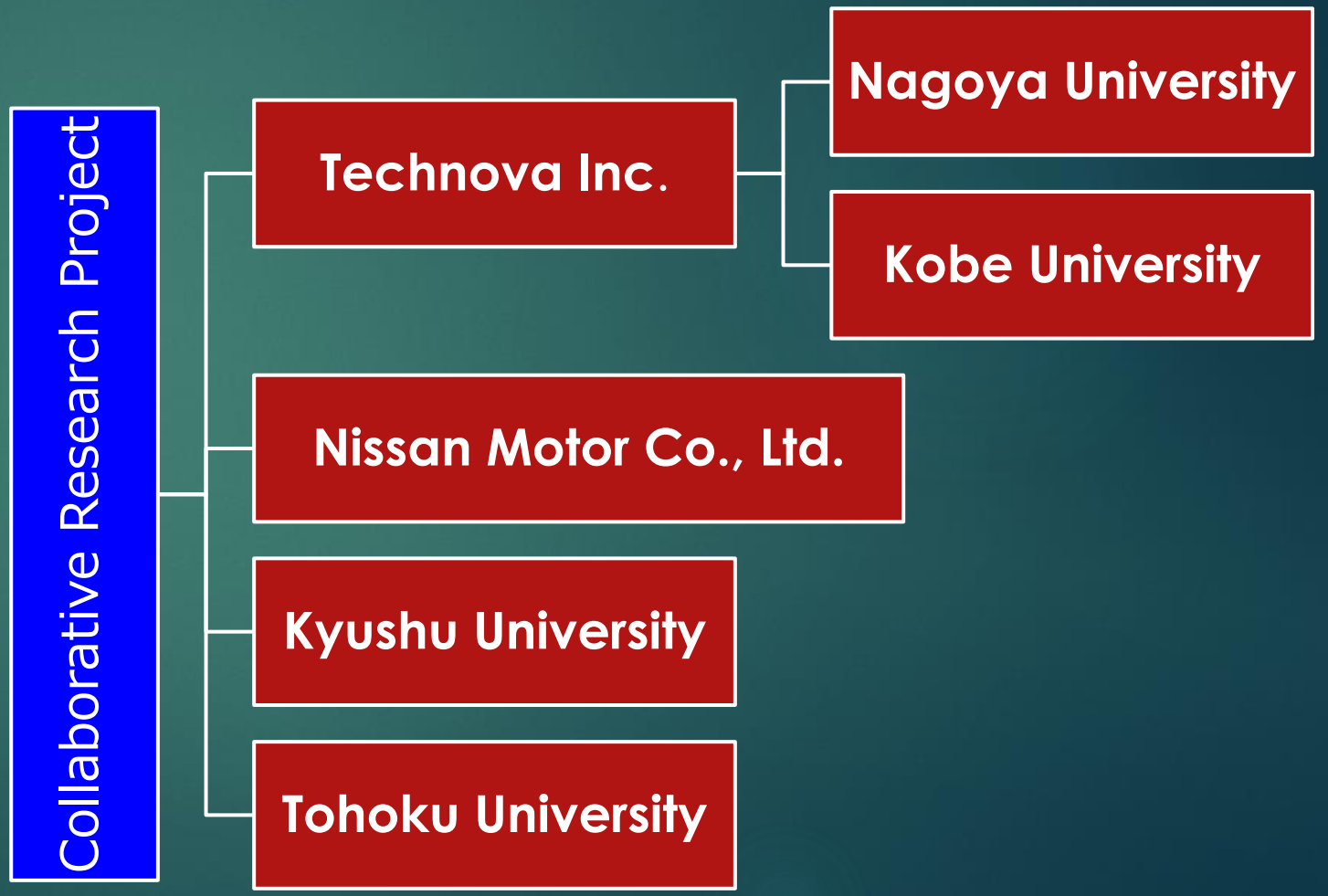
Collaborative Research Project (2015.10-2017.10)

Objectives

To clarify the **existence of the anomalous heat generation** phenomenon

Setup of a new **national project** by obtaining guiding principles on how to control the anomalous heat generation phenomenon .

Organization



Summary of Experimental Results at Tohoku Univ.

samples	Gas	Temp.	Results
PNZ4s ($PdNi_7/ZrO_2$)	D	160-300℃	1) Excess Heat 4-5W, Integrated H > **15eV/D** (1.4MJ/mol-D)
CNZ5s ($CuNi_7/ZrO_2$)	H	160-250℃	1) Excess Heat 2-5W, Integrated H >**68eV/H**(6.5MJ/mol-H) 2) **Coincident increase events** of the pressure of the reaction chamber and gas temperature
PSn1 (Pd/meso-Si)	D	200-300℃	**No Excess Heat at elevated temp.**
CNS3s ($CuNi_{10}/SiO_2$)	H(D)	150-300℃	1) In the case of H, Excess heat 2-4W, Integrated H > **110eV/H** (10.7MJ/mol-H) 2) No excess Heat in the case of D
CNZ6s ($CuNi_7/ZrO_2$)	H	150-350℃	**Coincident increase events** of the pressure of the reaction chamber and gas temperature were **replicated**

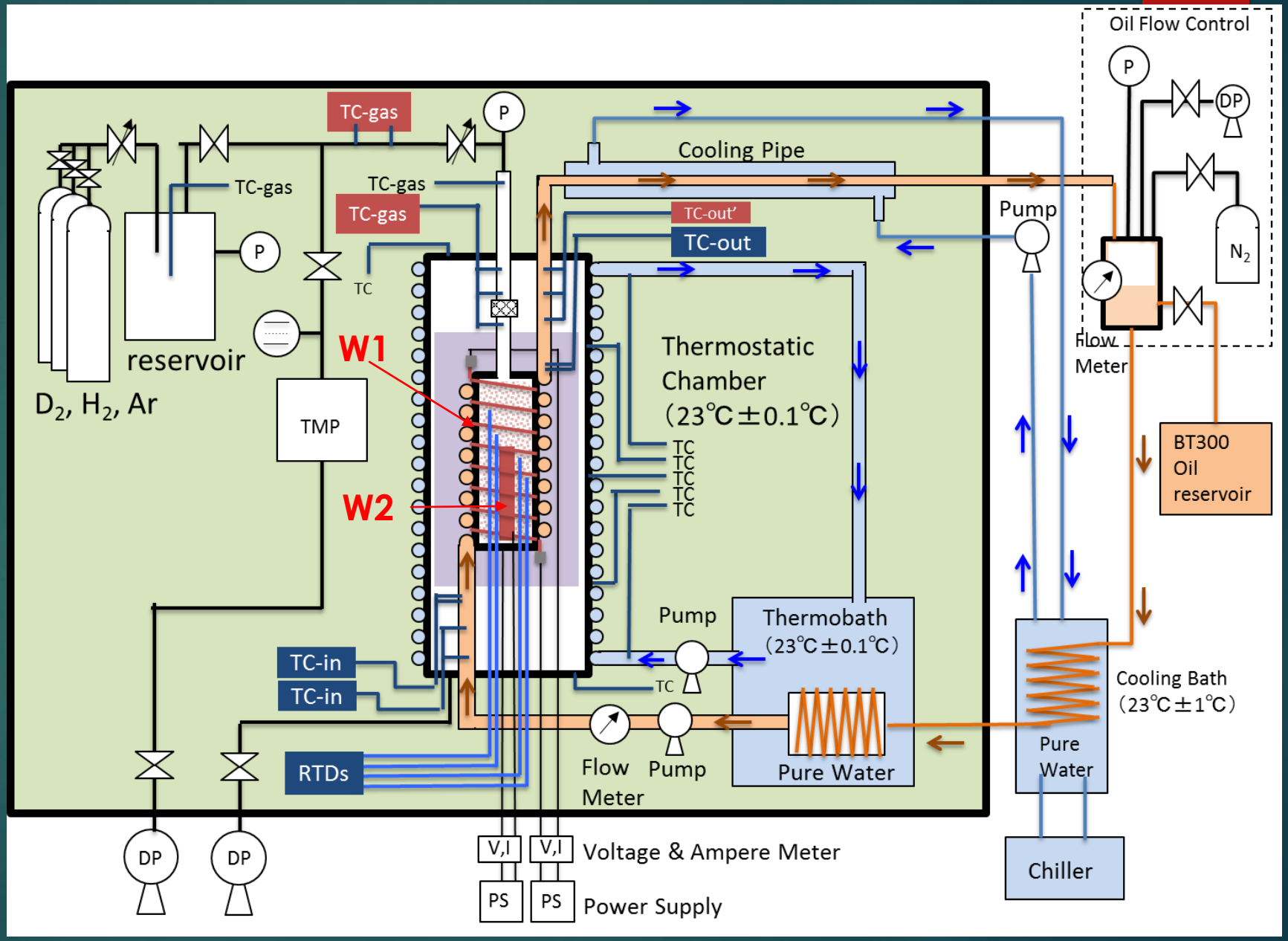
2. Experimental

Experimental Setup

Oil Flow-Calorimetry at High Temperature

A lot of Measurement Points

Resistant to Outer-Temperature Fluctuation



Appearance of Experimental Setup

Thermostatic chamber

Main experimental setup

Sample Preparation(ZrO_2)

at a Sendai Material Company

Melt Spinning

Amorphous Mixture of Metal Elements prepared by Melt Spinning method

at Kobe Univ. or Nissan

Formation of Nano Particles by Oxidization

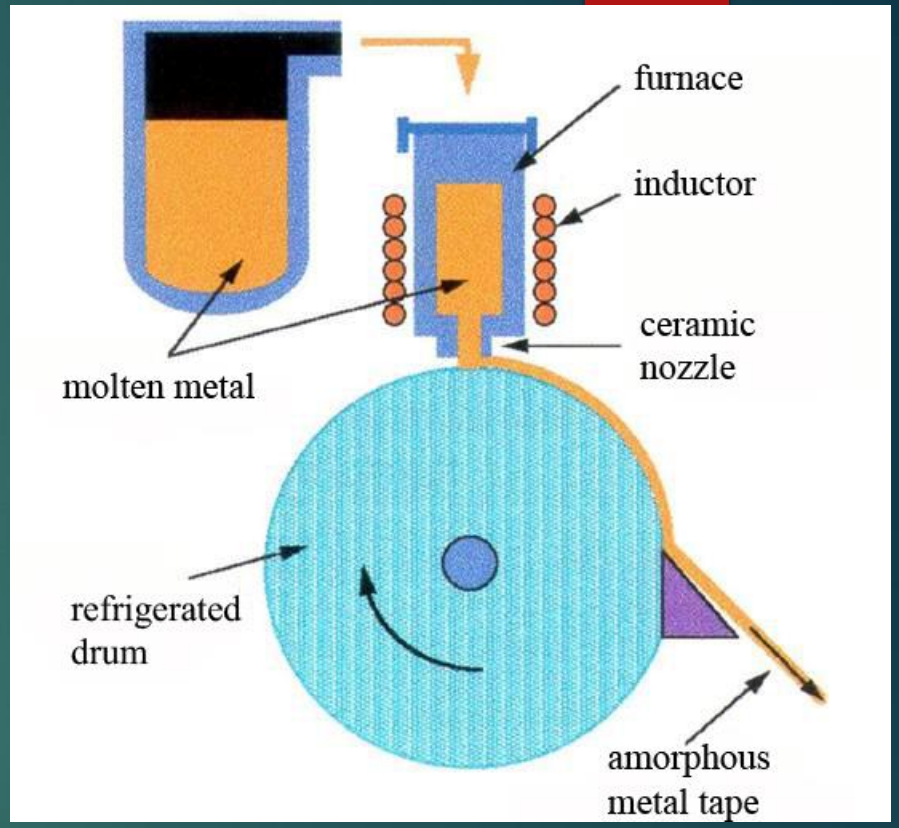
723K for 60 hr;
Preferential oxidation of Zr to ZrO_2

Experiment at Kobe Univ. PNZ4

Experiment at Tohoku Univ. PNZ4s

Two samples subjected to the same process

Schematic of Melt Spinning



$Pd_{0.04}Ni_{0.31}Zr_{0.65}$

or

$Cu_{0.04}Ni_{0.31}Zr_{0.65}$

Excess Power Evaluation

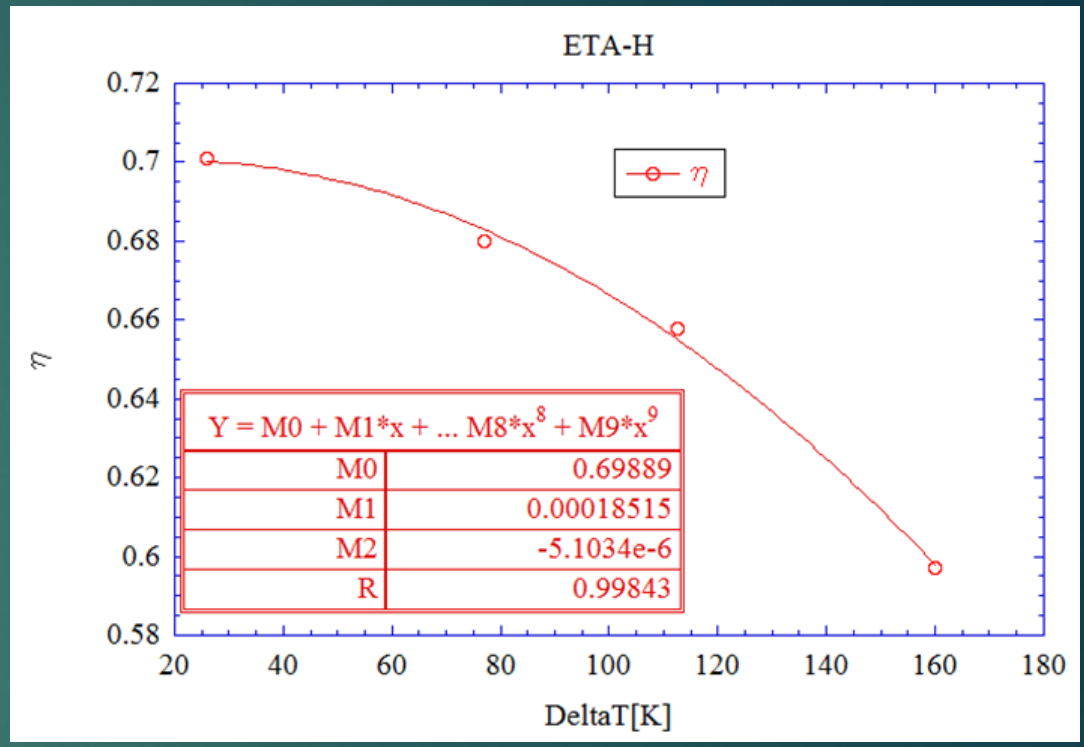
$$\eta Q = F_R \cdot \rho(T_{ave}) \cdot C(T_{ave}) \cdot (T_{out} - T_{in})$$

Flow rate Density Specific heat Delta T

$$Q = W_1 + W_2 + H_{EX}$$

Outer Heater Inner Heater Excess Heat

Input [W]	DeltaT[K]	Tin ave[C]	FL[ml/min]	Tave[C]	C[J/gK]	ρ [g/cm3]	η
15.01578	26.068338	25.115218	14.398465	38.149387	1.629708	1.03267692	0.701
47.13032	76.938459	25.88207433	14.339737	64.35130383	1.718794	1.0145976	0.680
73.47776	112.65535	26.624729	14.428727	82.952404	1.782038	1.00176284	0.658
115.963	160.02194	27.04636267	14.145065	107.0573327	1.863995	0.98513044	0.597



η (recovery rate) is estimated based on blank run data.
Then, H_{EX}(Excess Heat) is calculated by the above equations.

Error Estimation

$$EXH = \dot{m}C\Delta T / \eta - W$$

$$\delta(EXH) \approx |\delta(\dot{m})| \frac{C\Delta T}{\eta} + |\delta(\Delta T)| \frac{\dot{m}C}{\eta} + |\delta(w)|$$

Error factors

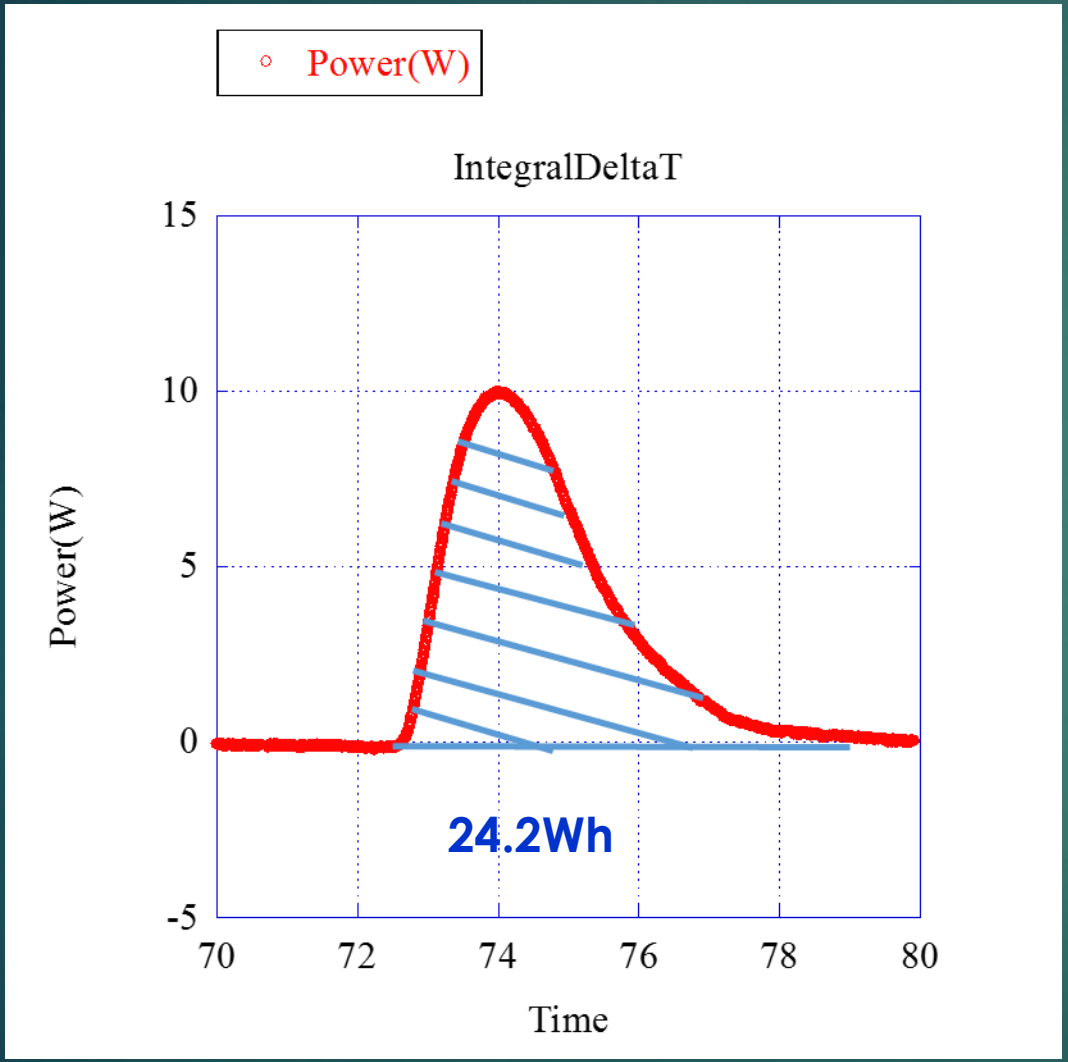
①Fluctuation of Oil Flow
②Fluctuation of Temperature measurement
③ Fluctuation of power input

Input [W]	δ (W)	DeltaT [K]	δ (DeltaT)	C[J/gK]	ρ [g/cm3]	FL[ml/min]	δ (FL)	η	$\lvert\delta(\dot{m})\rvert\frac{C\Delta T}{\eta}$	$\lvert\delta(\Delta T)\rvert\frac{\dot{m}C}{\eta}$	δ (EXH)
79.61	0.031	128.05	*0.261*	1.817645	0.994537	14.28	0.012	**0.692**	0.067	0.162	**0.260**
134.01	0.076	191.5	*0.390*	1.92143	0.973475	14.4	0.04	**0.641**	0.372	0.273	**0.721**

In the case of CNZ5s, σ = 0.3W for 80W Input , σ = 0.75W for 134W Input.
If we take 3σ for error range, we get **0.9W** for 80W and **2.3W** for 134W.

3-1 **PNZ4s** ($Pd_{0.04}Ni_{0.31}Zr_{0.65}$) with D_2 Gas

Heat Release at Room Temp.



$$E = \int Pdt = 24.22 * 3600 = 87.2[kJ]$$

PNZ4S;Tohoku

54.8kJ/D-mol

Absorbed D :1.59mol

0.57[eV/D]

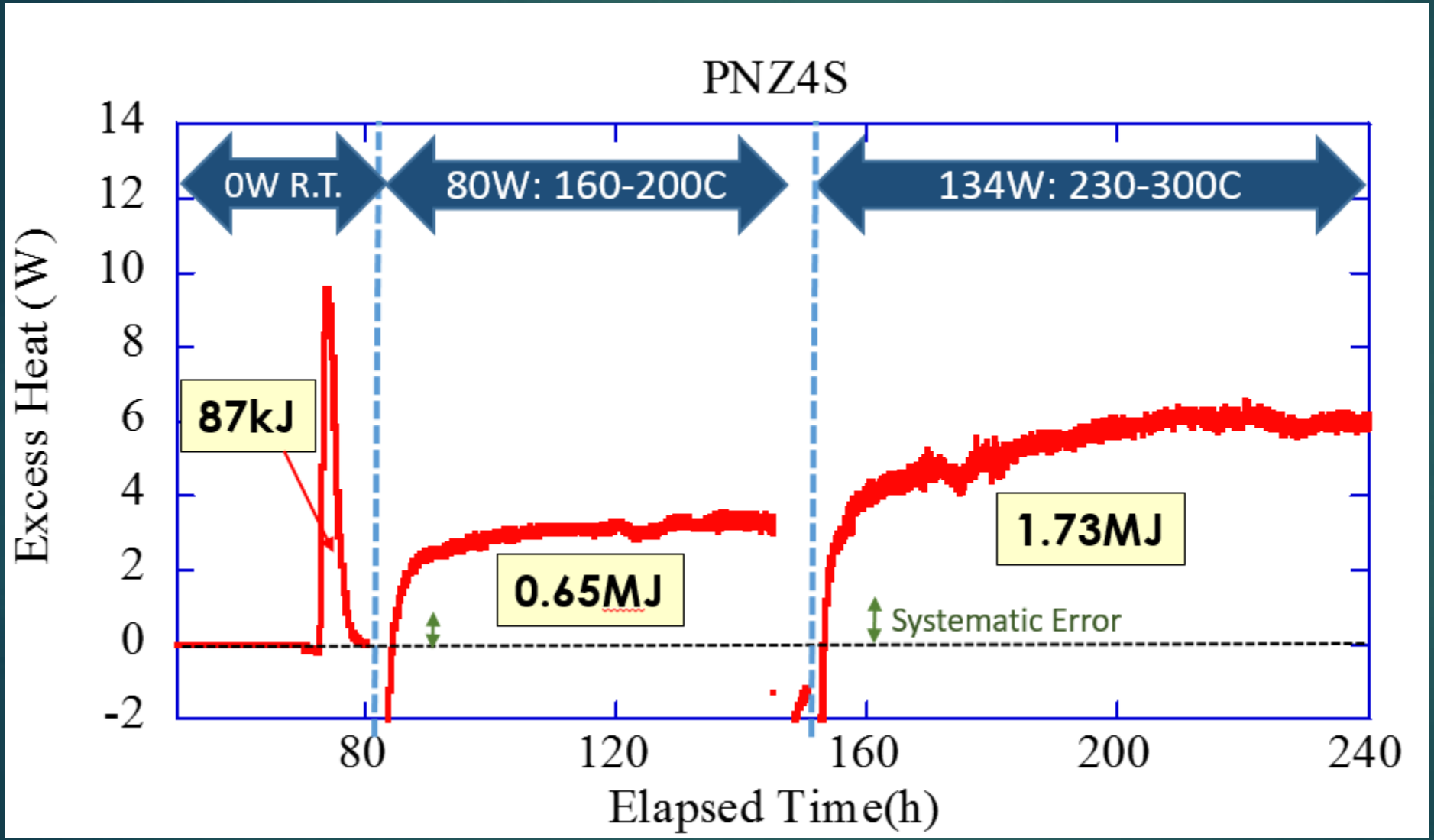
agree

PNZ4; Kobe

54kJ/D-mol

0.56[eV/D]

Excess Heat Generation: PNZ4s with D_2



Integrated EXH 2.47MJ

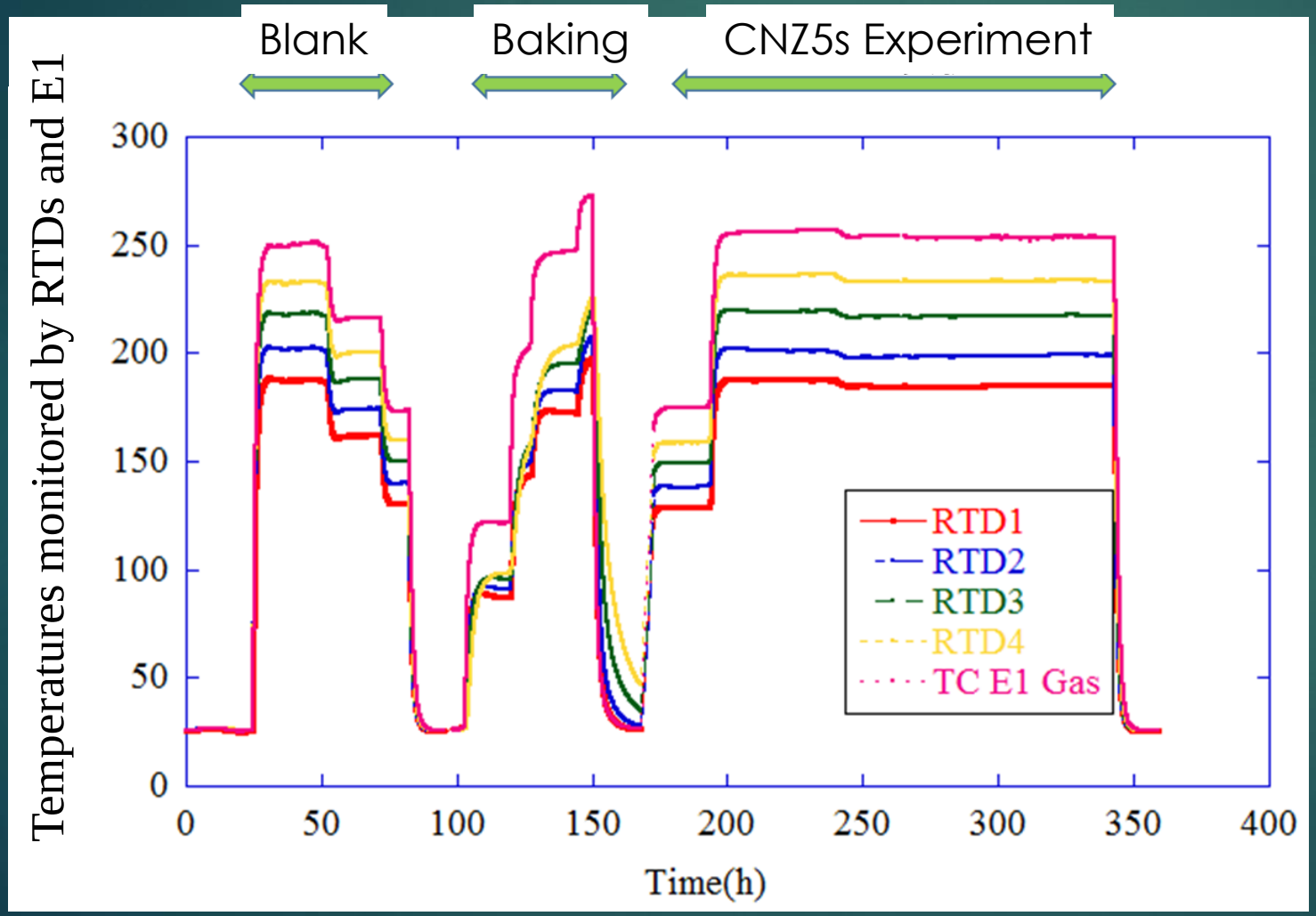
Absorbed D :1.73mol

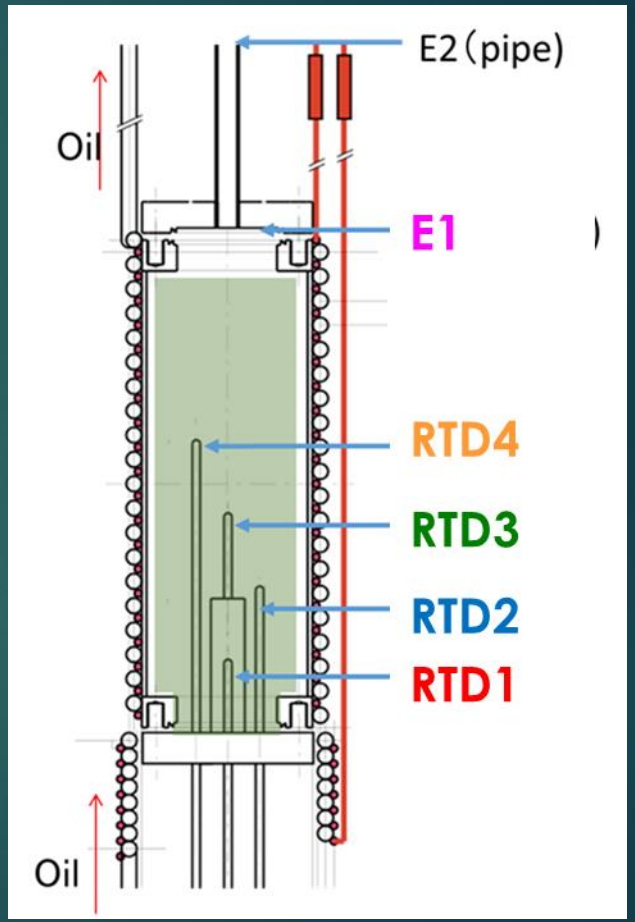
At Least 1,430kJ/D-mol 14.9eV/D

Cannot Explain by Chemical Reactions

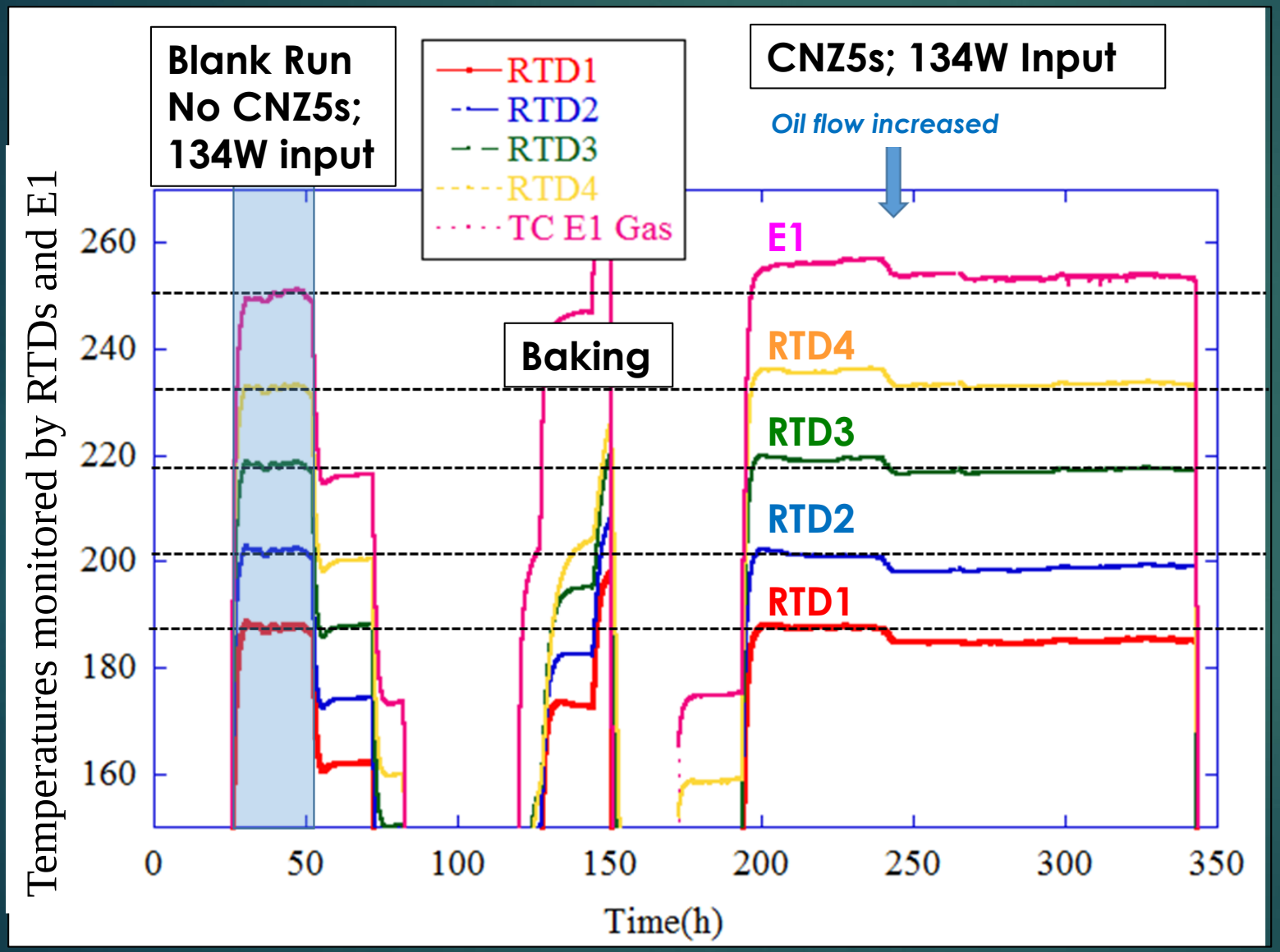
3-2 **CNZ5s** ($Cu_{0.04}Ni_{0.31}Zr_{0.65}$) with H_2 Gas

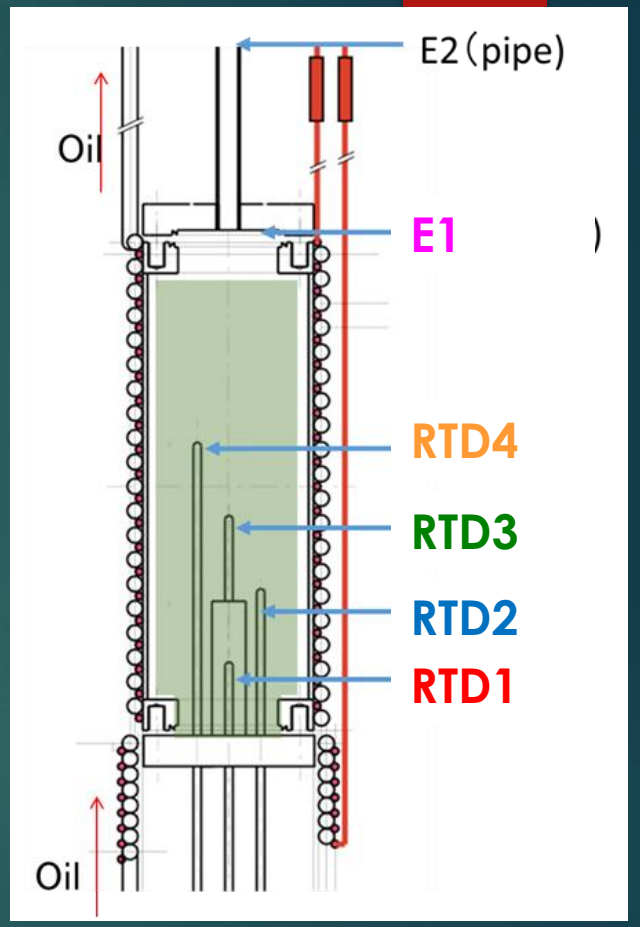
Overview of CNZ5s Experiment





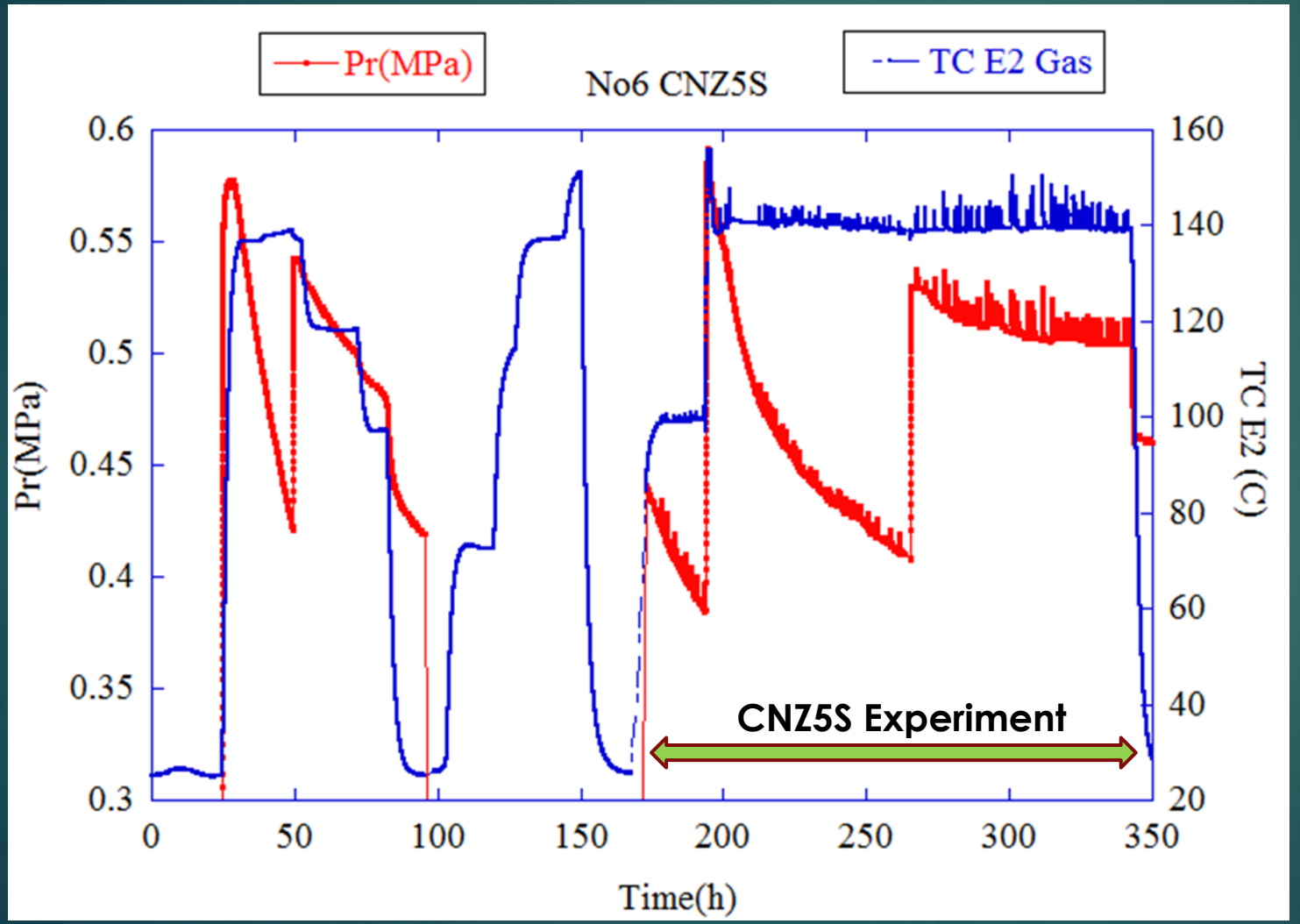
Comparison between RTDs and E1

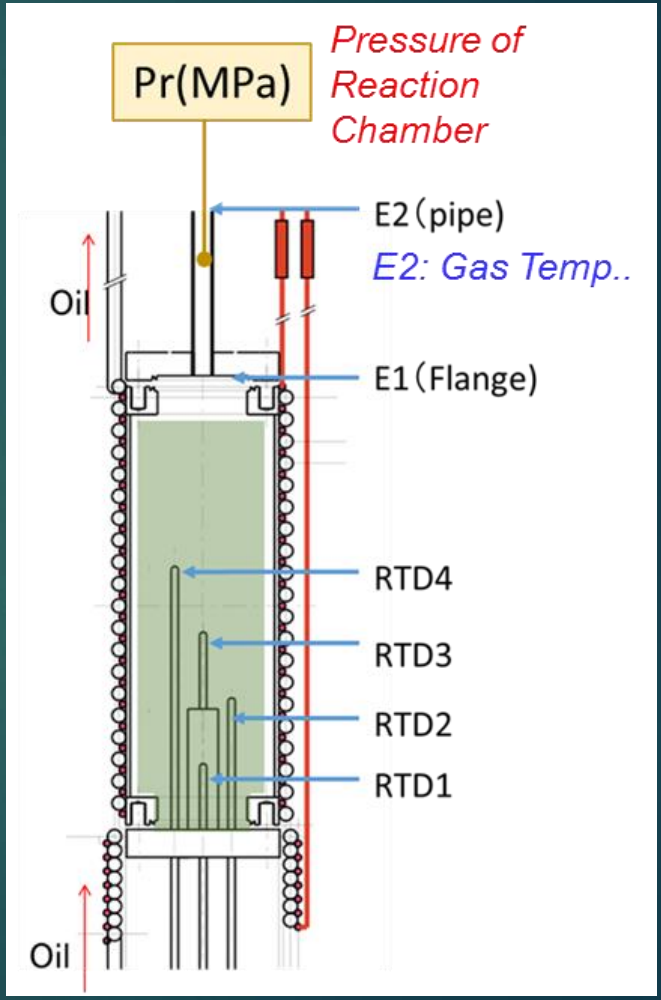




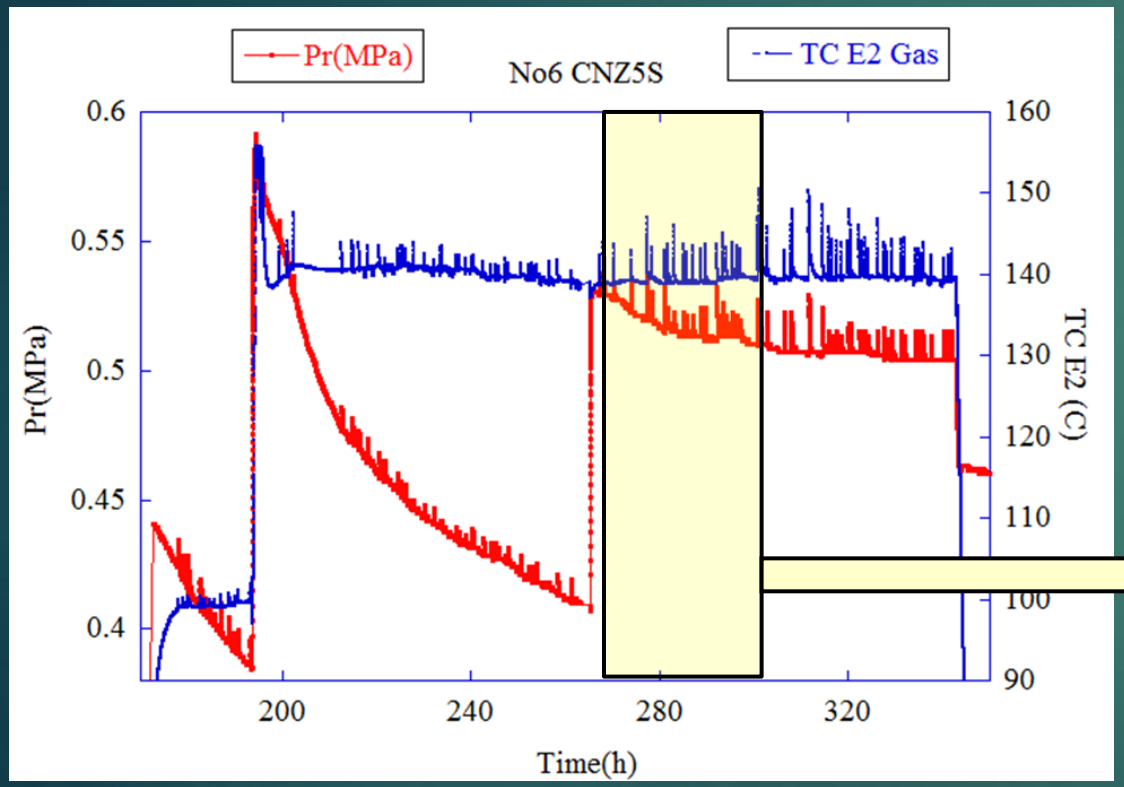
Temperatures of E1 and RTD4 are higher than those of Blank Run.

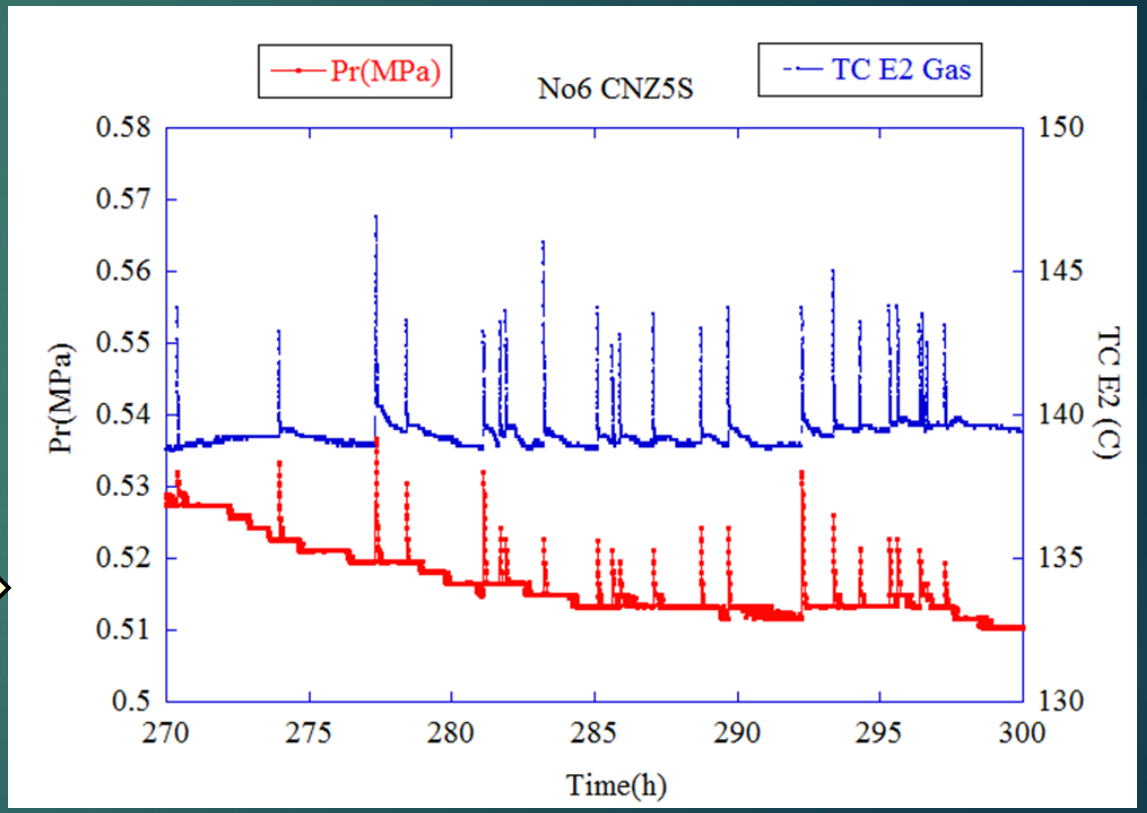
Fluctuations of Pressure of Reaction Chamber(Pr) and E2 Gas Temp.(E2) during CNZ5s Experiment





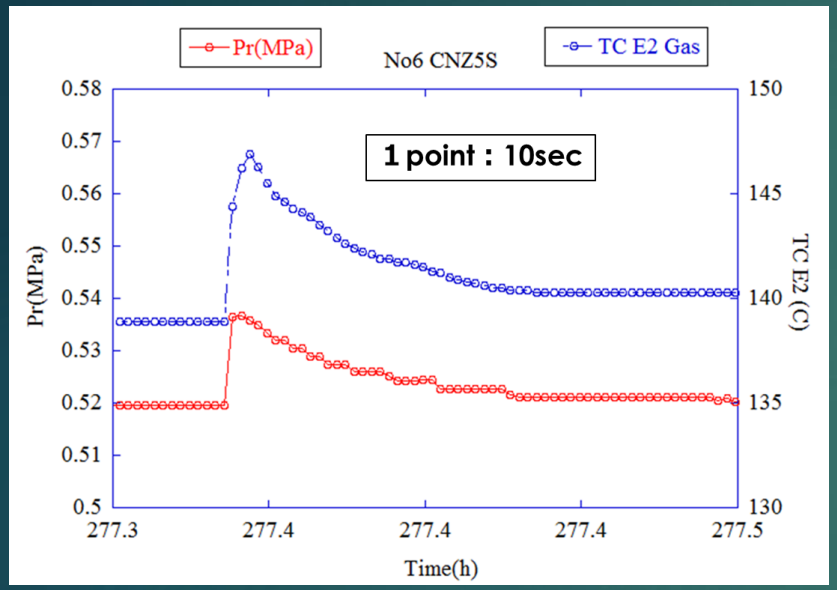
Coincident Increase of Pressure of Reaction Chamber(Pr) and E2 Gas Temp.(E2)

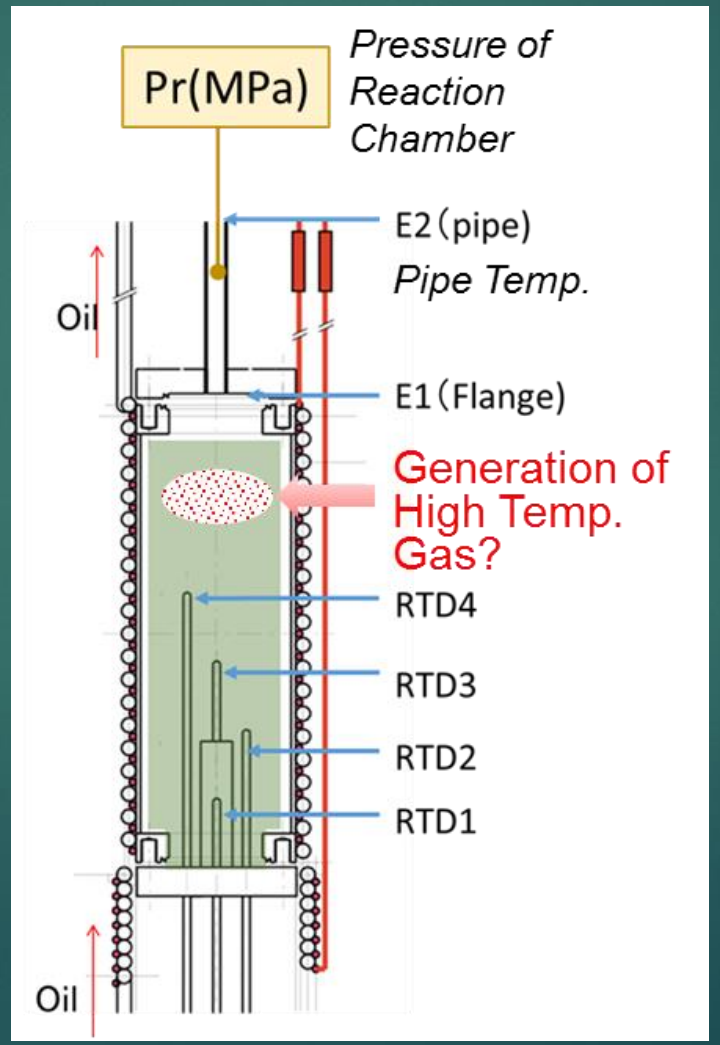




Time Scale enlarged

Coincident Increase of Pr and E2: Zooming Generation of High Temperature Gas ?

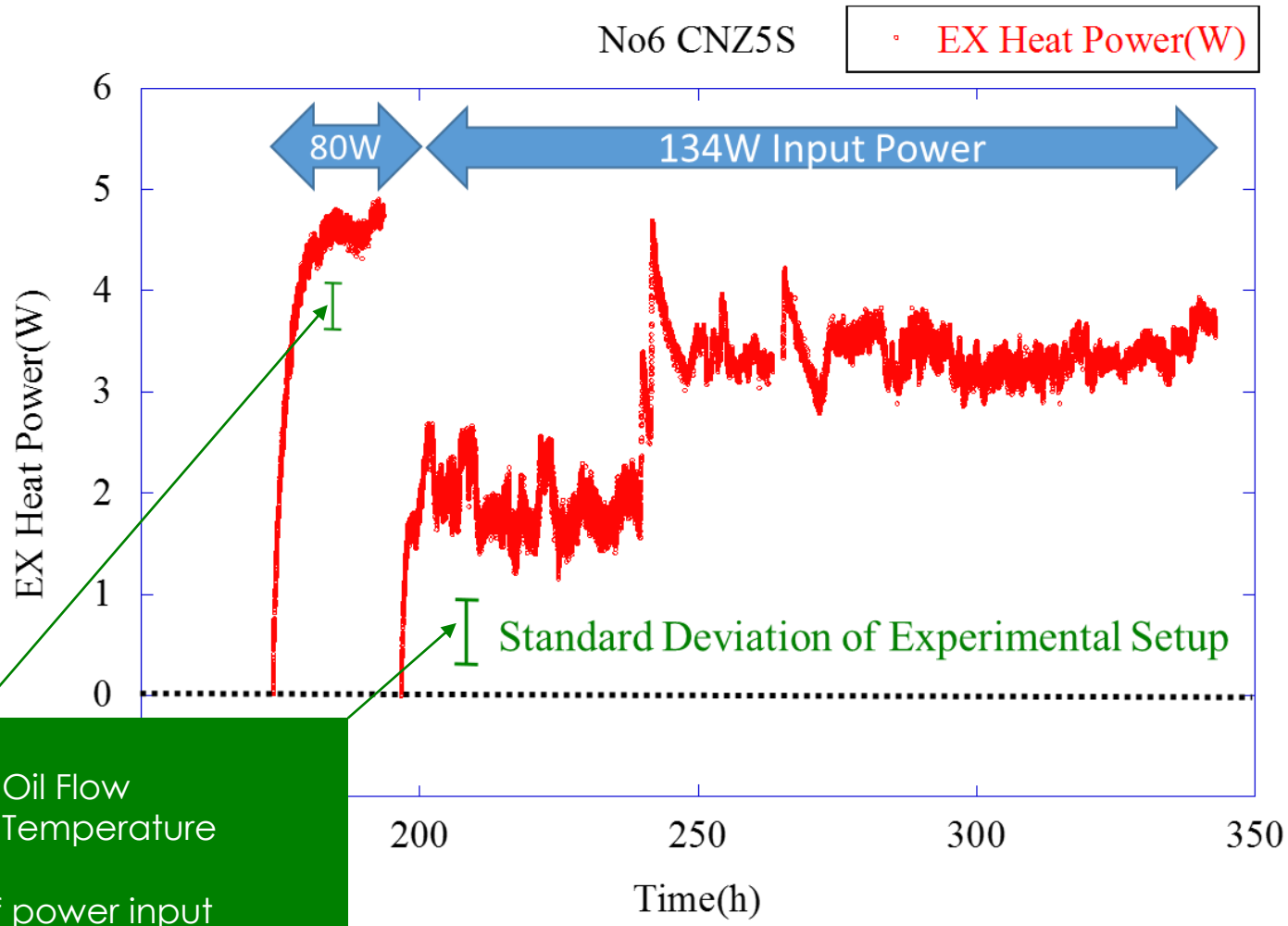




Generation of High Temperature Gas

- Pressure Increase of Reaction Chamber
- Temperature Increase of the pipe located at the top

Excess Heat Generation;CNZ5S with H_2



Error factors
①Fluctuation of Oil Flow
②Fluctuation of Temperature measurement
③ Fluctuation of power input

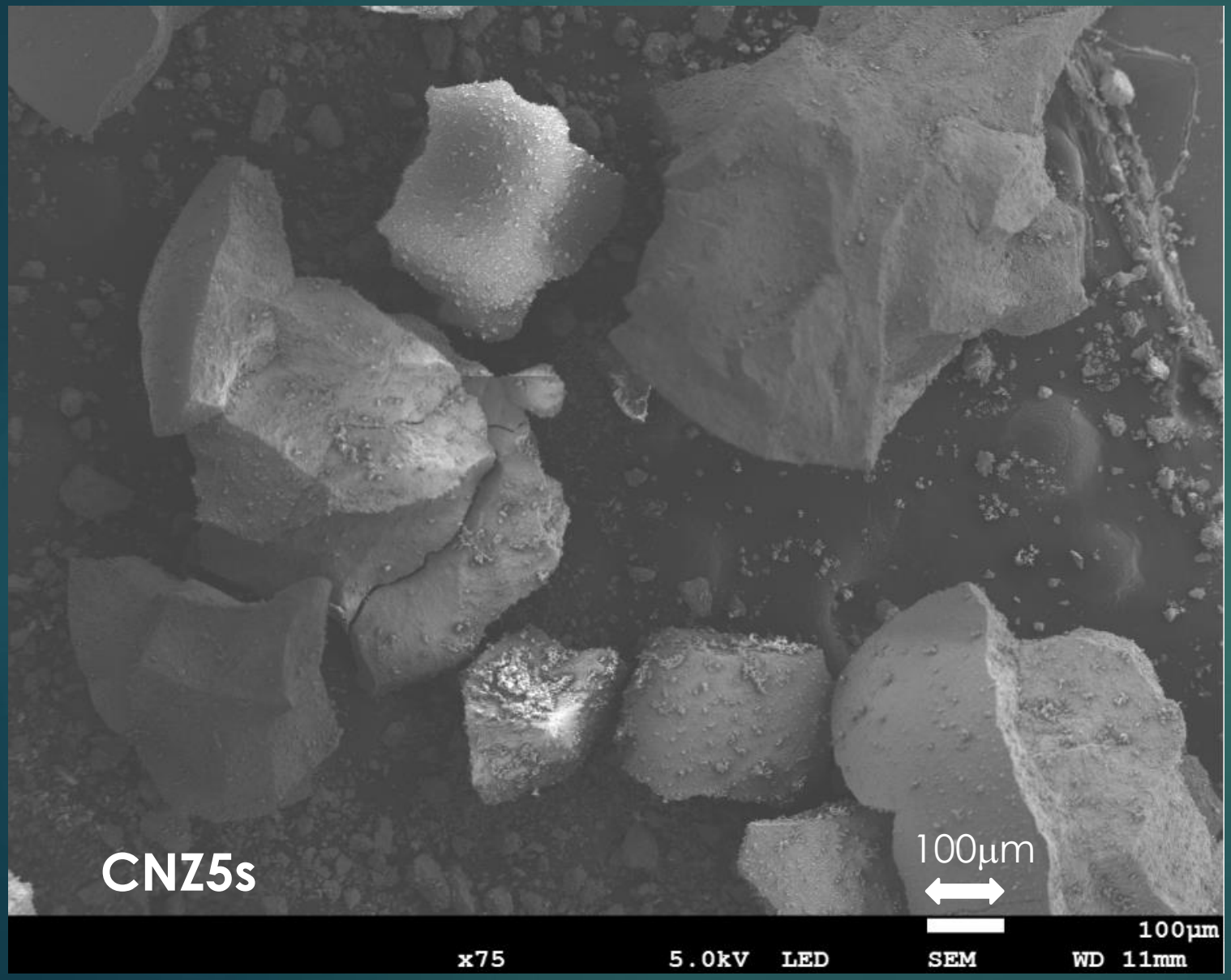
Int. Released Energy: 1.8MJ
Absorbed Hydrogen: 0.29mol

Released Energy per H
: **6.5 MJ/mol-H**
: **67.8eV/H**

Not Explained by Known Chemical Reactions

H absorption heat
: 42kJ/mol-H ($NiZr_2$)
H combustion heat
: 121kJ/mol-H
Reaction between Fe2O3 and Ni with H2
: 137kJ/mol-H
All NiO and Zr reaction
: 121kJ

Broken ZrO2 beads after excess heat release



The metal nano-composite samples; 100g-200g

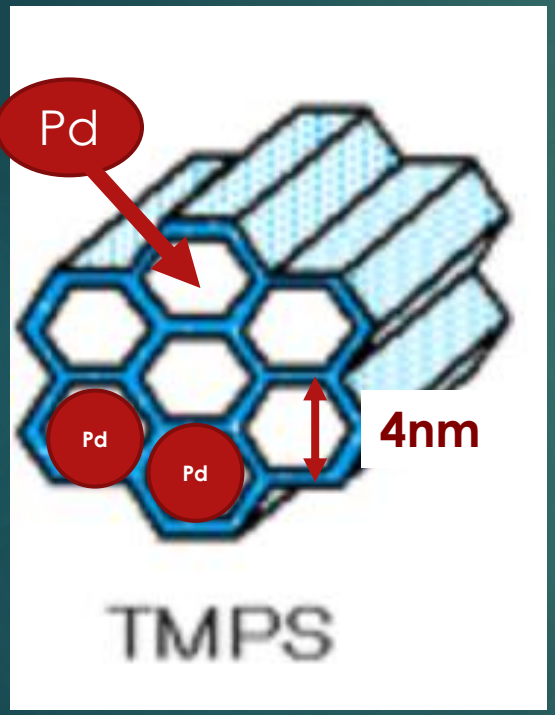
ZrO2 beads (1mmϕ); 1,400g

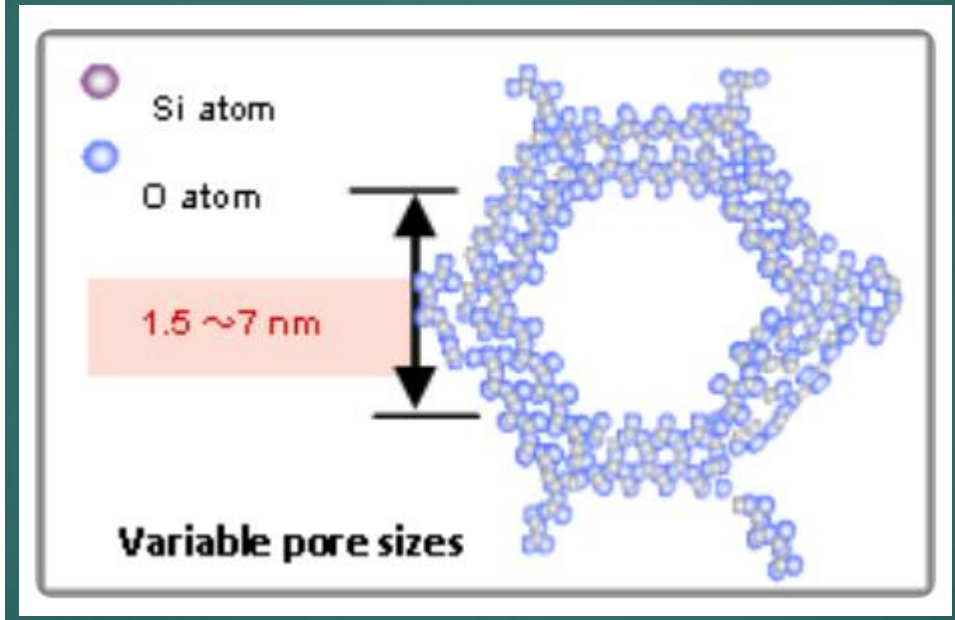
The sample was **sieved** out to separate from ZrO2 beads (1mmϕ). But we found that some **broken parts of ZrO2 beads** were mixed with the metal nano-composite sample.

Suggests that **very large local heat stress** was loaded on ZrO2 beads.

3-3 PSn1;Pd/TMPS-4R with D_2 Gas

Nano-Pd embedded in Mesoporous Silica with 4nm hole prepared by Nagoya Univ. (PSn1;Pd/TMPS-4R)





PSn1; 112.4 g

-No filler-

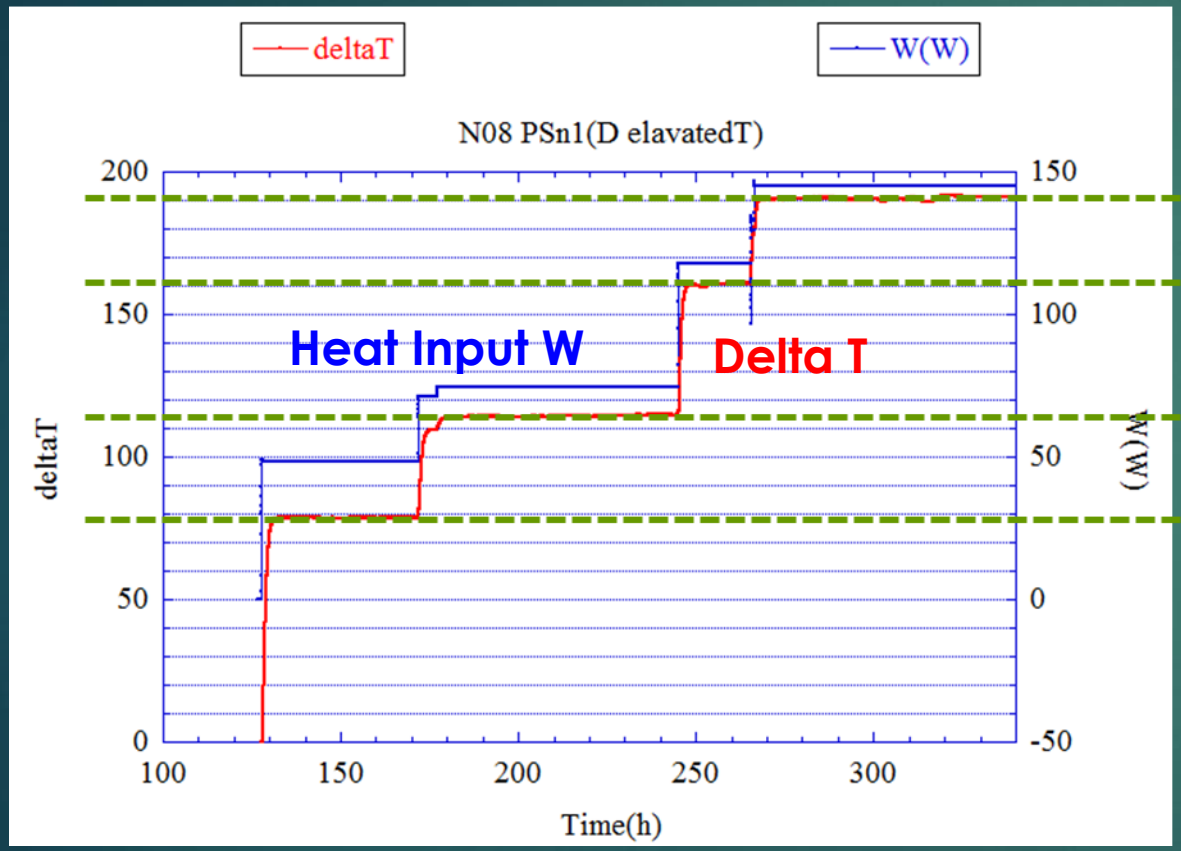
Pd; 7.52 g

PdO; 8.65 g

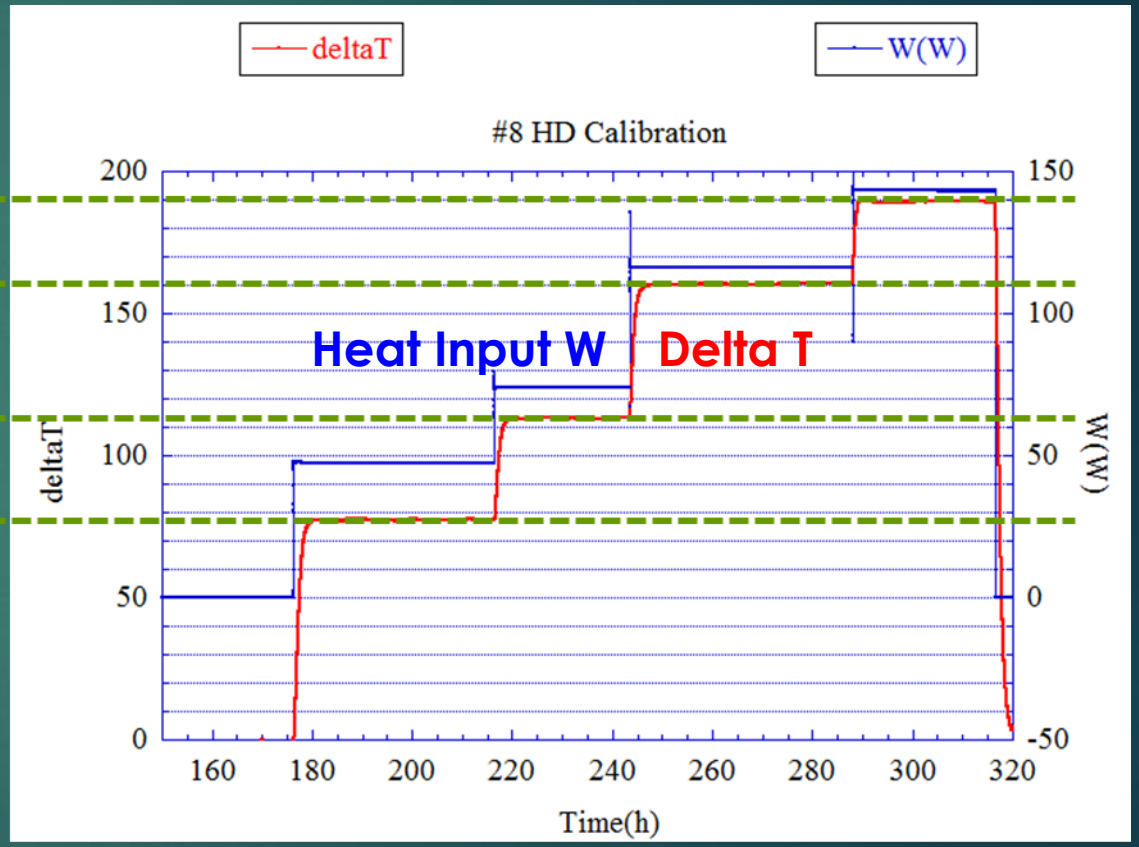
http://www.taiyointernational.com/products/mesoporous-silica/

Excess Heat Evaluation ; No Excess Heat

Psn1; Elevated



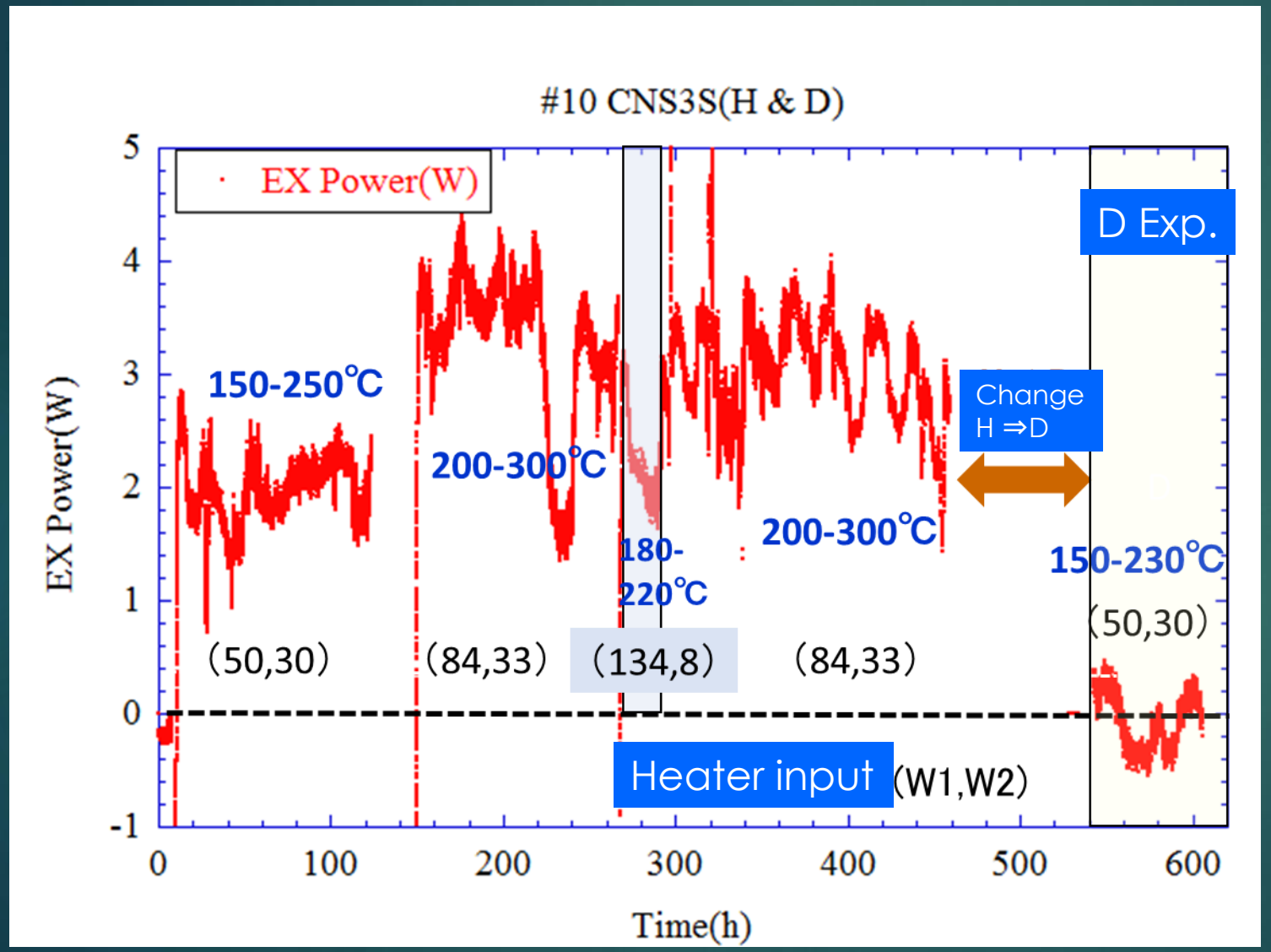
Blank Run



No excess heat observation in the case of Pd only samples.

3-4 CNS3s; with H_2/D_2 Gas

CNS3s ; Excess Heat at elevated temp.



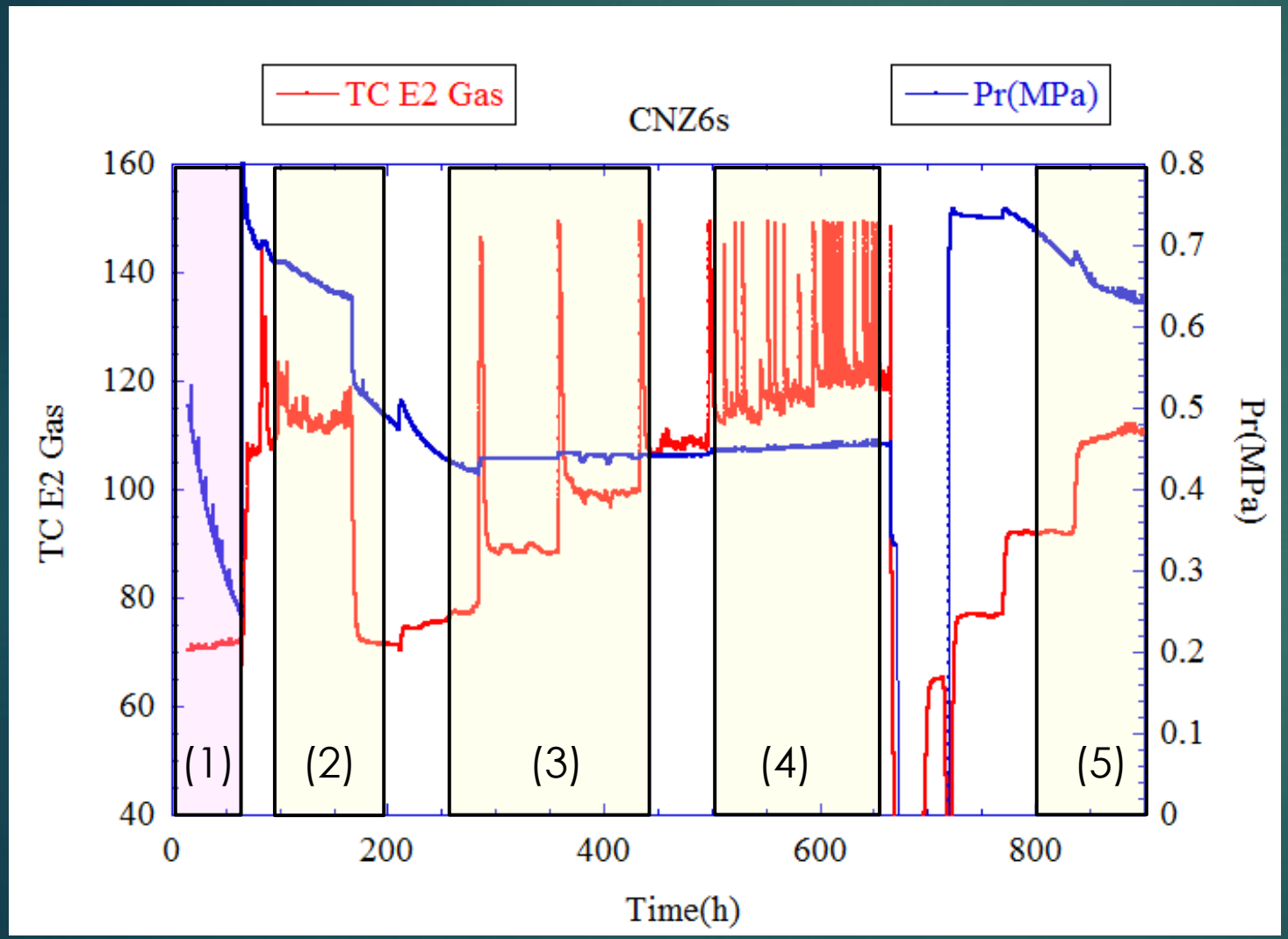
It seems that **higher temperature in the reaction chamber** is important factor for anomalous heat generation.

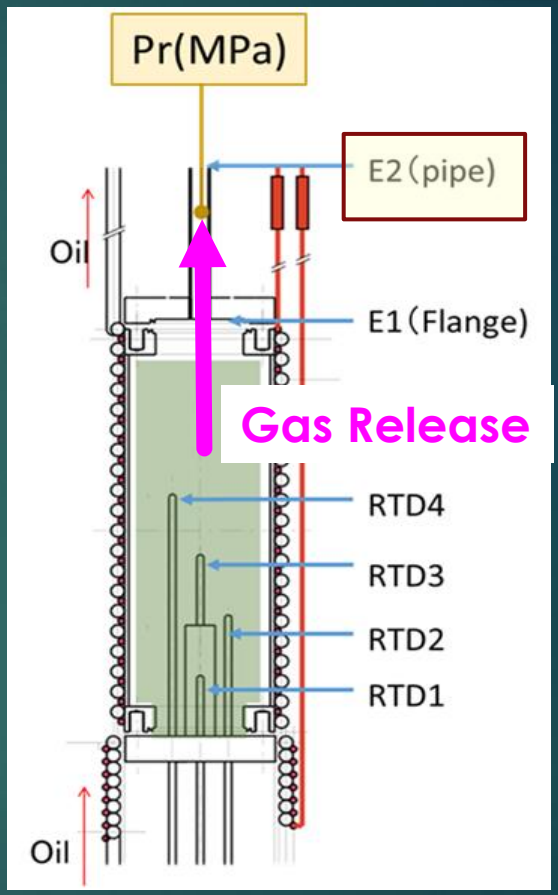
When we changed H_2 to **D_2** gas, we observe **No excess heat**.

Generated Energy
10.7MJ/mol-H
110eV/H

3-5 CNZ6s; with H_2Gas

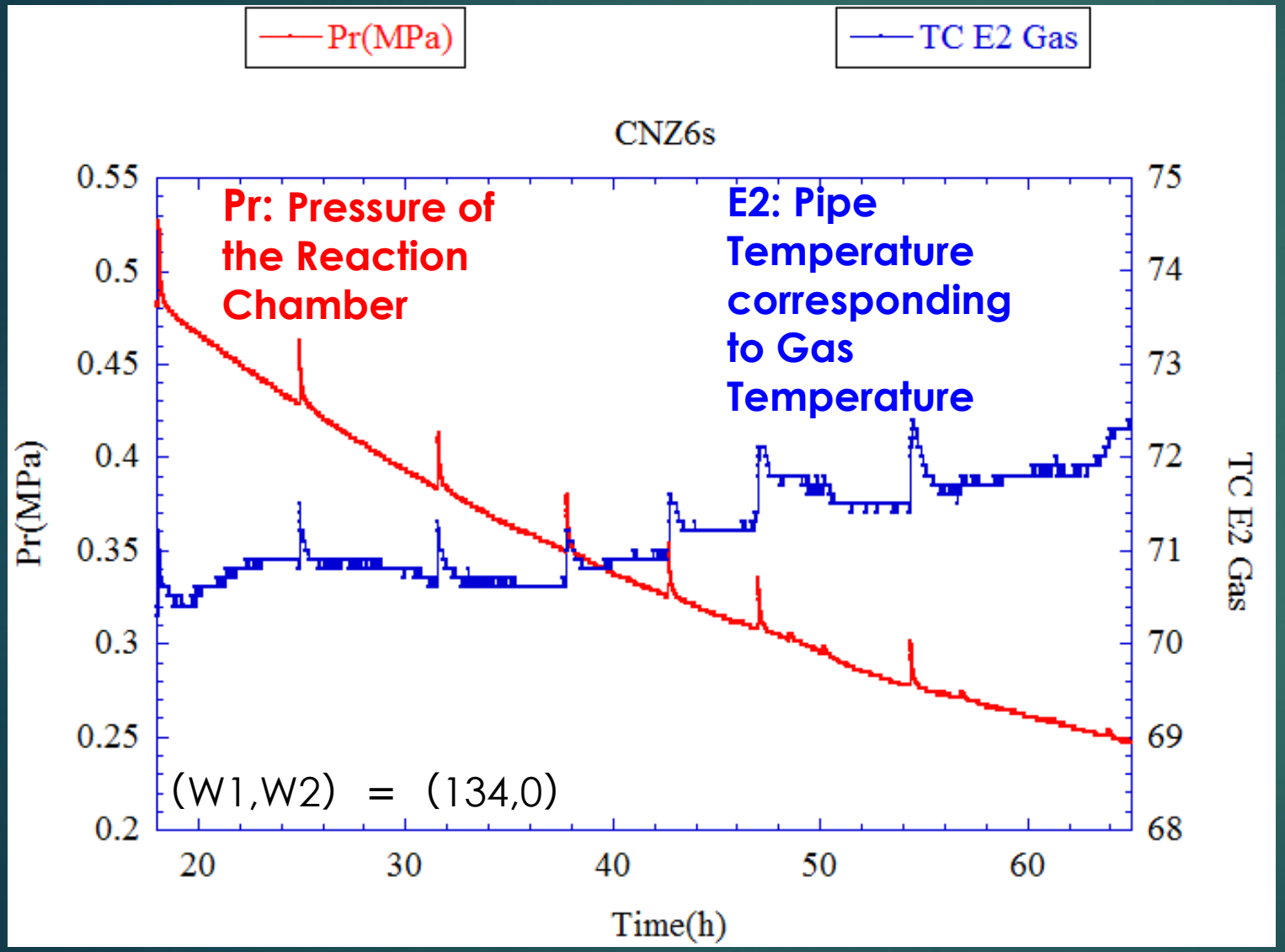
Coincident increase events of E2 and Pr

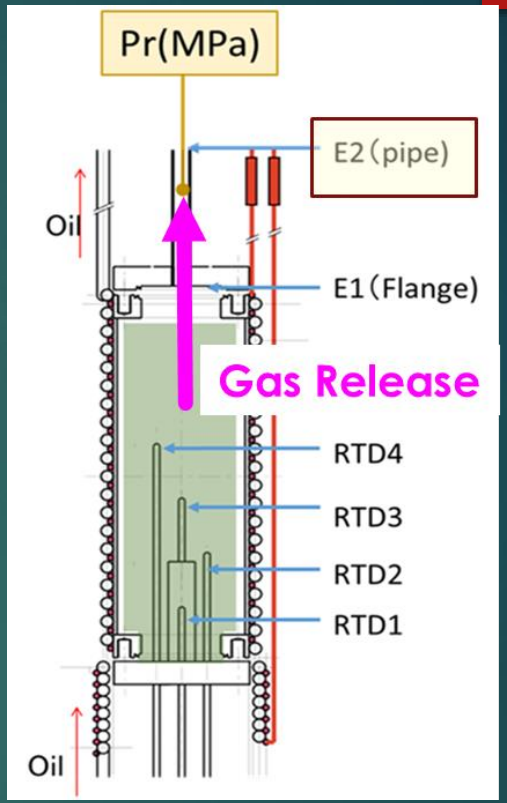




Burst-like Coincident increase events similar to CNZ5s were observed.

Replication of Coincidence Events at (1)





Coincident increase events of the pressure of reaction chamber and gas temperature were **replicated**

Concluding Remarks

- **Anomalous excess heat generations** were observed for all the samples at elevated temperature (150℃-350℃), except for the Pd nanoparticles embedded in mesoporous SiO_2.
- Integrated excess heat reached **more than several MJ/mol-H(D)** which could **NOT be explained by any known chemical process**.
- **Coincident burst-like increase events** of the pressure of reaction chamber and gas temperature, which suggested sudden energy releases in the reaction chamber, were observed many times for an experiment using the **$Cu_{0.044}Ni_{0.31}Zr_{0.65}$ (CNZ5s)** sample. These burst-kike events were replicated during the experiment using the same composition sample; **$Cu_{0.044}Ni_{0.31}Zr_{0.65}$ (CNZ6s).**
- **Qualitative reproducibility between Kobe and Tohoku** experiments was good.

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