Test of Energy Catalyzer

Bologna September 7, 2011

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New model of the E-cat

At this occasion, a new model of the E-cat was used. As in previous models heat was supposedly generated inside a reactor by a reaction between nickel powder and pressurized hydrogen in presence of unknown catalysts. The reaction was "ignited" by heat from an electric resistance, in this version only one resistance.
The new version was much larger than the previous models, approximately 50 x 60 x 30 centimeters, and also heavier, about 80 kg, when empty of water. According to Andrea Rossi the increased dimension is due to a larger volume inside where the water is heated, approximately 30 liters, and a larger heat-exchanger with a greater surface which should result in a more effective heat transfer from the reactor to the circulating water and also in additional heating of the steam after vaporization. Increased weight should partly be due to additional lead shielding. Water, which is fed into the E-cat by a peristaltic pump, is supposedly in direct contact with the heat-exchanger which is mounted on the reactor. No other liquid or circuit is used for heat transport, according to Rossi.

Observations:

Temperature:

Room temperature was between 30°C and 31°C.
T2 – temperature incoming water
T3 – temperature at output, inside the E-cat

Calibration peristaltic pump:

Water was collected in a small pot for 2:08 minutes. Net weight was 562 grams, which gives a flow of 4.39 grams/s or 15.8 kg/hour.
During the test the water flow was lower (see below).

17:23 Hydrogen was filled after having checked that there was no pressure inside the E-cat. The bottle was attached, opened, closed, and detached.

Weight hydrogen bottle:

- before filling:	13613.4 grams
- after filling:	13610.7 grams
Total loaded:	2.7 grams

Pressure H_2 Bottle: 60 bar Reduced: 20 bar

18:05 With all systems off, AC voltage was measured to be 231 volts. DC voltage was zero. Input current was zero.

18:15 The reservoir for input water was filled with 15640 grams of water.

18:30 Pump was started after the E-cat was checked to be empty.

18:35 The control box was switched on. Over all input AC current was 0.139 A. DC current was insignificant.

18:59 Power to the electric resistance was set to the value “5.” on the control panel. The system apparently switched on and off the power intermittently about every second, which resulted in an input AC current that went continuously between zero and 11.4 A. The AC current feeding the resistance was also measured and found to go between zero and 11.4 A. DC current was insignificant. AC voltage over the resistance went between zero and 212 volts. DC voltage was zero.
T2=29.5°C, T3=29.4°C.

19:10 Power was raised to “6.”. All values were stable but while the power was still switched on and off, the interval with power on was slightly increased and the interval with power off was decreased.
T2=29.3°C, T3=29.6°C.

19:20 Power was raised to “7.”. Interval with power on was increased further.
T2=29.0°C, T3=31.4°C.

19:21 Added water to input reservoir, 9380 grams.

19:30 Power was raised to “8.”. Interval with power on was increased further.
T2=29.7°C, T3=34.6°C.

19:33 Added water to input reservoir, 9473 grams.

19:37 Added water to input reservoir, 9959 grams.

19:40 Power was increased to the maximum value, “9.”, and power was at this point constantly switched on. Input AC current was 11.6 A. Over-all AC voltage was 218 volts. DC voltage was zero.
AC current feeding the resistance was 11.5 A. AC voltage over the resistance was 211 volts. DC voltage zero.
T2=29.9°C, T3=40.6°C.

20:16 Drops of hot water started to overflow at the output.
T2=29.6°C, T3=68.1°C.

20:50 Overflow was approximately 3,7 grams/s or 13 kg/hour.
T2=29.3°C, T3=90.3°C.

20:55 Overflow decreases.
T2=29.2°C, T3=93.4°C.

21:05 T2=29.1°C, **T3=100.0°C.**
Input AC current 11.8 A. Over-all AC voltage 218 volts.

AC current feeding resistance 11.7 A. AC voltage over the resistance was 213 volts. DC voltage zero.

21:07 Net weight of water in input reservoir 8431 grams.

21:08 Added water to input reservoir, 10089 grams.

21.10 Added water to input reservoir, 10460 grams.
T2=21.4°C, T3=102.5°C.

21:20 T2=29.9°C, T3=108.2°C.

21:30 T2=30.3°C, T3=111.8°C.

21:40 T2=30.2°C, T3=115.1°C.

21:50 T2=29.3°C, T3=118.8°C.

21:50 Liquid water at the outlet was measured and found to vary between 1.4 and 1.8 grams/s or from 5.0 to 6.5 kg/hour.

22:00 T2=29.3°C, T3=122.9°C.

22:10 T2=29.2°C, T3=126.6°C.

22:20 T2=29.1°C, T3=129.6°C.

22:30 T2=29.0°C, T3=131.9°C.

22:35 Power to the resistance was cut off.
Input AC current was 0.11 A. Over-all AC voltage was 232 volts. DC voltage was zero.
AC current through the resistance was 0.11 A.
T2=29.0°C, T3=**133.0**°C. *(Typo corrected Sept 14).*

22:40 T2=28.9°C, T3=133.7°C.

22:50 T2=28.8°C, T3=131.2°C.

22:52 Added water to input reservoir, 6591 grams.

22:53 Added water to input reservoir, 9960 grams.

23:00 T2=29.3°C, T3=127.4°C.

23:10 Pump stopped. Hydrogen pressure was decreased.
Inlet valve was opened letting out steam and hot water.
T2=29.3°C, T3=122.7°C.

23:15 T3=116.5°C.

23:20 T3=100.3°C.

23:25 T3=101.5°C.

23:29 T3=105.0°C.

Remaining water in the inlet reservoir: 22823 grams.

Hot water emptied from the E-cat through the inlet valve: 22463 grams.

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Note 1: The test was ended at 23:10 on our request, for practical reasons and lack of time. We had at that point not yet analyzed the data and had not realized that one or two more hours would have given clearer results.

Otherwise we would have continued. Supposedly this Ecat needs 10 minutes of full power electric input after every 30 minutes of self sustaining operation, for stability reasons, in the worst case.

Electrical measurements

The electrical connection was made through a residual-current device to make sure that no current was fed through the ground cable.

The over-all voltage was monitored continuously with a digital multimeter. DC voltage was measured at several times and found to be zero.

A clamp ampere meter was used to measure the current fed to the whole system as well as the current feeding the electrical resistance.

The difference was found to be insignificant at all times.

When setting power to the electrical resistance to zero on the control panel, the AC current measured through the resistances fell to 0.11 A. Over all DC voltage was found to be zero.

Water flow inlet

Added water during start up, from 18:30:
15640 + 9380 + 9473 + 9959 = 44452 grams.
Remaining in the inlet reservoir when the temperature inside the E-cat reached 100°C at 21:07: 8431 grams.
Consumed in 2:37 hours (2.62 hours): 36021 grams
Flow during start-up: 13.76 kg/hour

Added water from 21:07:
8431 + 10089 + 10460 + 6591 + 9960 = 45531 grams.
Remaining in the inlet reservoir at 23:10: 22823 grams.
Consumed in 2:03 hours (2.05 hours): 22708 grams
Flow during boiling: 11.08 kg/hour.

Total running time >100°C: 2:05 (2.08) hours

Total flow >100 degrees (from 21:05): 23.0 kg

Water flow outlet

The water directly from the outlet of the E-cat was measured collecting drops and splashes of water in a pot, without any hose attached at the outlet. The amount of liquid water was found to vary between 1.4 and 1.8 grams/s or from 5.0 to 6.5 kg/hour.

Part of this water might be condensed steam inside the E-cat, but in a worst case scenario it can be considered not evaporated.

Vaporization

Steam quality was not measured. Some things could be noted though.

- Steam at the outlet was invisible, which is hard to see in the video. This is an indication of high steam quality.

- Temperature inside the E-cat was well above 100°C, up to 133°C. We could assume, but we don't know for sure, that this was the steam temperature.

- Pressure in the E-cat should have been close to atmospheric as the outlet seemed absolutely open -- splashes of water came out freely and initial overflowing was noted before boiling.

- Using only the input electric power (2.6 kW) and assuming that the liquid water at the output was never vaporized, the steam quality at the given water flow would be about 60% (see Note 3 below). It should not be significantly lower. If it on the other hand was higher this indicates excess energy developed by the Ecat.

Energy calculation:

The energy calculation of this test has proven to be difficult. We had limited time to plan and perform the test, and analyzing the data we realize that we would have needed more data for a fair calculation.

We can look at the situation from two sides.

1. One is looking at the amount of water being heated and vaporized.

The amount of water heated to 100 degrees (assuming that the pressure is close to atmospheric as the outlet seemed open, which we saw when water was overflowing before boiling) should be the same as the amount of water pumped into the E-cat.

The amount of water being vaporized could conservatively be considered the amount of water pumped into the Ecat, minus the liquid water coming out at the output. We have to note that this water could partially be condensed steam, and thus evaporated, but we assume that it was never evaporated.

As we only have one value of the liquid water at the outlet, during the boiling phase with electric heating, we have to assume that this value is valid also at the self sustained phase. An additional value from the self sustained phase would have been important.

However, assuming all values constant, this would lead to the energy produced being constant throughout the boiling phase, with or without electric heating.

That would lead to the conclusion that at the moment of switching off the electric resistance, the reactor would have had an instant increase in power to compensate for the loss of electric heating, which is implausible.

Possibly the reactor could have been increasing its power at this moment, compensating slowly for the loss of power.

Consequently this calculation could be used only to calculate the average power developed during the boiling phase.

2. The other side is more qualitative than quantitative.

We observed during the boiling phase with electric heating switched on that there was a strong steam flow – which is difficult to observe in the videos – and a clear sound of boiling inside. The inside temperature reached above 130 degrees which either indicates a high pressure between 2 and 3 bars, which is unlikely as the output seemed to be totally open (water did overflow freely before boiling initiated), or that steam is effectively heated after vaporization by the heat exchanger inside the Ecat.

When switching off the electrical resistance the temperature started to fall slightly but not dramatically. Boiling continued and steam kept flowing at the output.

The impression was that the loss of heating power was minor. Consequently the heat produced by the E-cat in self sustained mode should have been clearly larger than the heat from the power that was lost when the electric resistance was switched off.

Using the measured values, the electric resistance fed 2.6 kW into the E-cat, and thus the E-cat reactor should have produced clearly more than this amount of heat in itself.

The decrease in temperature after switching off the electric resistance could be explained assuming that the electric resistance was in connection with the heat exchanger, and when it was switched off, the part of the heat exchanger that was not submerged in water would slowly have been cooled down. Consequently it would have heated the steam slightly less than before.

An overall energy calculation for the time interval when the temperature was above 100°C (21:05 – 23:10) would give this:

Inlet water temperature, T3 (conservatively): 30°C
Boiling temperature: Presumed 100°C
$\Delta T = 70$

Heat capacity of water is 4.18 kJ/(kg x K)

Energy required for heating water, W_{heat} = 292.6 kJ/kg = 81.3 Wh/kg

Enthalpy of vaporization is 2260 kJ/kg. Energy required for vaporization, W_{vap} = 627.8 Wh/kg.

Worst case scenario:

Total mass of water consumed with electrical heating, m_{tot} = 23.0 kg

Liquid water at the outlet, worst case: 6.5 x 2.08 = 13.52 kg

Mass of presumed evaporated water, m_{vap}: 9.48 kg

Total energy produced $W_{heat}+W_{vap} = 81.3 \times m_{tot} + 627.8 \times m_{vap}$ =
81.3 x 23.0 + 627.8 x 9.48 = 7821 Wh

Average net heating power in 2:05 (2.08) h: ≈ 3.8 kW

Note 2: This would be the worst case, assuming liquid water at the outlet was never evaporated. The values of produced energy and power should not be lower. Potentially they could be up to 16.3 kWh and 7.8 kW respectively.

The contribution from the electric resistance should be:

11.8 A x 218 V = 2.6 kW

Note 3: The energy from the electric resistance is not enough to sustain the vaporization even in the worst case scenario. Thus this energy could not be stored in the Ecat. Even assuming a steam quality of 59%, which would only require 1330 kJ/kg for evaporation, all the electric energy would have been consumed in the worst case scenario. As the steam at the outlet was invisible, such a low steam quality seems unlikely.

Note 4: The energy that was required to heat the water inside the Ecat to 100°C at the end of the start-up phase, at 21:05, was supposed to be the same as the energy in the hot water emptied from the Ecat at the end of the test, and was therefore not calculated.

Conclusion:

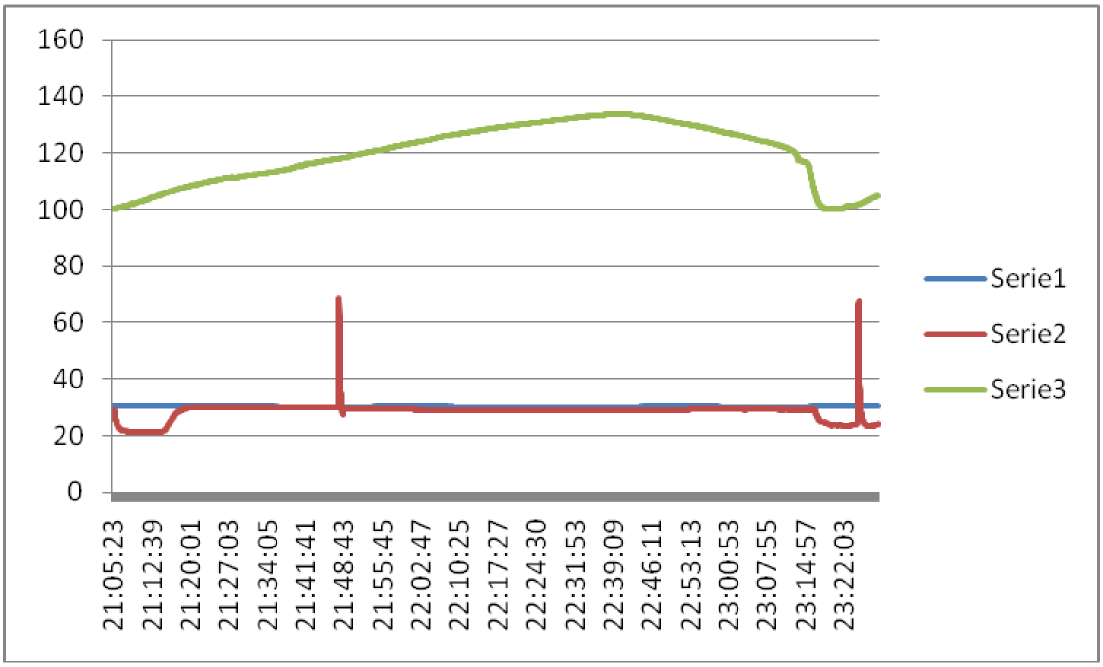
* Average overall power developed after boiling should have beeen approximately 3.8 kW, in a worst case scenario, assuming that all liquid water at the output was never evaporated. Possibly this value could have been up to 7.8 kW.

* As input electric power was 2.6 kW, the excess power developed by the E-cat should initially have been in the order of at least 1 kW, in the worst case scenario.

* As only a slight decrease in temperature was observed when the electric resistance was switched off, and as no energy could have been stored inside the device, the excess power developed by the E-cat should have been clearly larger than the electric power fed through the resistance at the beginning of the self sustained mode. The overall energy calculation also indicates this and the power from the E-cat in self sustained mode should thus have been about 3.8 kW in the worst case scenario.

* As this model of the E-cat was significantly larger and heavier, it was not as obvious as with previous models to completely exclude alternative energy sources inside the E-cat. This was partly due to the fact that we chose to terminate the test after only 35 minutes of self-sustained operation.

Temperature curve from 21:05:



Note: Jumps in Serie2 (inlet water temp) are due to the probe being pulled out of the water for short moments.

Instruments

* Peristaltic pump NSF
Model # CEP183-362N3
Serial # 060550065
Max output 12.0 liters/h
Max press 1.50 bar

* Temperature logger Testo
177-T3
0554 1765 Usb Interface

* Scale
Model: TKW 15 S
S/N: 2917029003
Max 15000 g
d= 0.1 g
Certified according to ISO 9001:2000

* Clamp Amperemeter Digimaster DM201
1090647637

* Clamp Amperemeter Mastech MS2102 AC/DC
10030032671

* Multimeter Hung Chang HC-5010C

* Residual-current device, Co Tech EMP200S-1, Ref 32-3492

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