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# Investigation of new version of the device similar to high-temperature Rossi heat generator

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***Abstract*—This paper describes a new version of the device similar to high-temperature A. Rossi heat generator, which operated continuously more than three days. The assessment of excess power is made (about 500 W, the relation of produced to consumed power is about 2.4). In total about 150 MJ of excess energy is produced during this experiment. Analyses of nuclear and isotope composition of fuel mix before and after the experiment are performed.**

Experiments with devices described in [1] showed that the mixture Ni + $Li[AlH_4]$, heated in a hermetically closed ceramic tube to temperatures higher than 1100°C, produce significantly more heat than the used energy. However, the working time of these reactors is too short to produce measurable isotopic or atomic changes and thus to show that the release of the excess heat is caused by cold nuclear transmutations.

For achieving a longer continuous operation, the construction of the reactor was significantly changed. First of all we had to reject calorimetry based on the measurement of the quantity of evaporated water [1] because it is difficult to make all day addition of water.

## I. Construction of the reactor

The structure of the reactor intended for long-term tests is shown in Fig. 1. The reactor tube has the internal diameter of 5 mm and the outer diameter of 10 mm. Its horizontal size is of 29 cm, and only the central part (7 cm) is heated. Due to a low thermal conductivity of the ceramic, ends of the tube are not very warm (at 1200°C in the center the ends are not warmer than 50°C); this allows using the epoxy hermetic for closing the tube.

The heater made from Kanthal A1 that can operate up to 1400°C. The fuel mixture (640 mg Ni + 60 mg $LiAlH_4$ is in a container of thin stainless steel. Nickel powder tipe of -2 is used. For displacing the air from the tube we have used ceramic inserts. The manometer with a maximal pressure of 25 bars is connected with the reactor by a thin stainless steel tube.

## II. Equipment for heater power supply, measurement of the consumed energy and control of temperature

The electroheater is connected to the power supply network via the thyristor regulator. For an operating control of power consumption the AC amperemeter and voltmeter are used. Since the thyristor regulator distorts a sinusoidal form of AC current, such devices (ampermeter and voltmeter) are not suitable for a precise measurement. For more exact measurement of the consumed electric power the electronic watt-hour meter "Mercury 201.5" is used. It is allow not only to display the amount of the consumed electric power, but also provides an interface to PC for registering the consumed electric power on a computer.

For control of reactor temperature the thermocouple of type  is used. Hot junction is placed on surface of the reactor tube in the middle of a heating zone. The signal from the thermocouple is displayed by the pointer indicator and is registered by a computer. The signal from the thermocouple is also used for adjusting the power provided to the electric heater so that the set temperature is maintained.

The computer used for registration of temperature had to be periodically switched off in order to recharge the accumulator. During this time the temperature control was performed by the pointer indicator and by the recorder H-370, which plotted the measured temperature on a paper.

## III. Change of temperature and pressure during the reactor operation

Fig. 4 shows a temperature dynamics during the heating and the necessary power for achieving the set temperature. The temperature of 1200°C at the reactor surface was attained in 12 hours of stepwise increase of temperature with the maximal power of heater about 630 W. After this the power required to maintain the temperature of 1200°C decreases to 330W in 1 hour.

Fig. 5 shows the change of pressure in the reactor camera during the heating compared with the growth of temperature. The increase of pressure starts around 100°C. Maximum pressure of app. 5 bar was achieved at 180°C. After this the pressure starts to fall and at 900°C was smaller than atmospheric. The greatest decrease (-0.5 bar) was attained at 1150°C, then it starts slowly to increase to the atmospheric pressure.

Fig. 6 shows the power of electro heater for 4 days until the heater wire is burned out as a result of its gradual oxidation.

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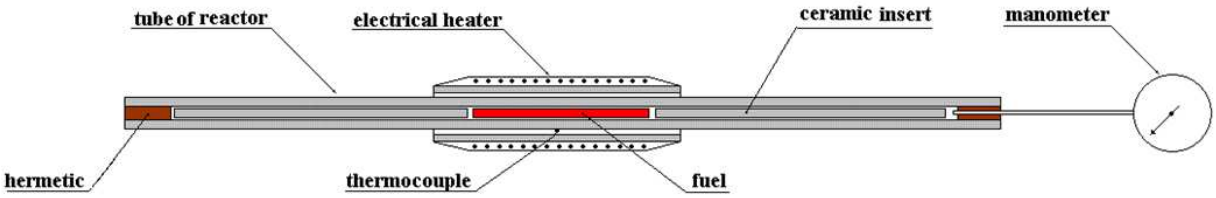


Figure 1. Structure of the reactor designed for a long-term operation.

For almost 3 days the power necessary to maintain the temperature of the reactor tube at 1200°C was in the limits of 300-400W (fig.6). Before the burning out, the power started to increase and at burning out it was 600W. The burning out was caused by gradual oxidation of heater's wire.

## IV. Operating the reactor with a new heater

The reactor was switched on in one day with the same reactor tube, but with a new heater. Fig. 7 shows the power consumed by the reactor after replacement of the heater. Unlike the first attempt, here an essential decrease of power consumption after achieving the temperature of 1200°C was not observed. The power required for maintaining the temperature at 1200°C was within the limits of 600-700 W, i.e. it was approximately at such amount, which was at the time of burning out the first heater. Only at the end of this attempt the reactor's power consumption decreased a little.

Approximately in one day after repeated switching the reactor, it was switched off by a gradual deceleration of a heater power.

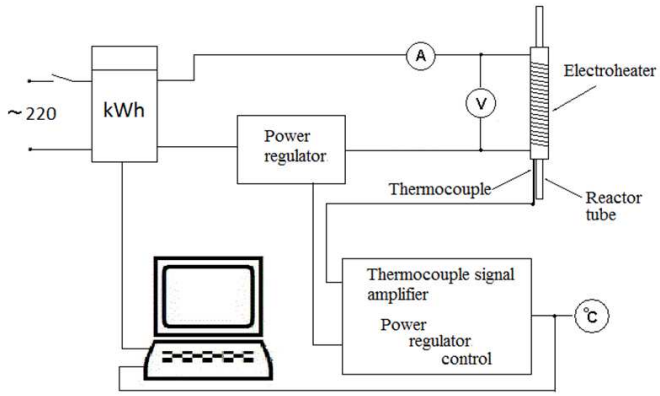


Figure 2. Scheme of heater power supply, measurement and adjustment of power consumption and temperature.

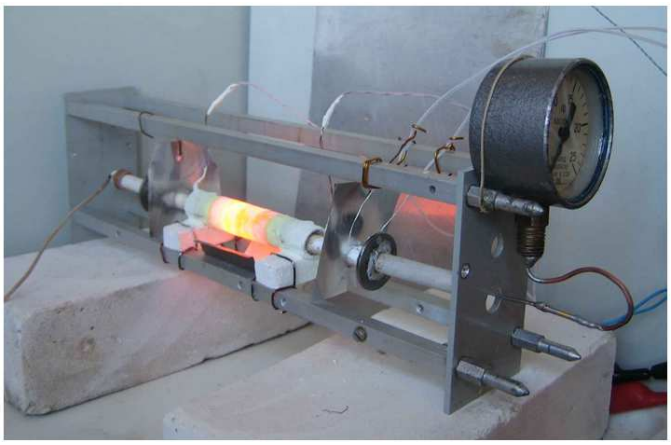

Figure 3. Reactor during testing.

## V. Control of radiation

In order to measure the level of radiation, the СИ-8Б Geiger counter and the ДК-02 dosimeter were used. These devices were also used in experiments [1]. For neutron measuring a neutron-activation technique with indium was employed. Measurements showed that the level of ionizing radiation during the reactor operating time did not exceed the background level considerably.

## VI. Ratio of produced heat and the consumed electric power (COP)

Since a direct measurement of generated heat was not performed in the described experiment, the reliable estimation of generated heat is challenging. This problem can be solved by a comparison of reactor parameters with fuel mix and without fuel mix.

Fig. 8 shows the power that is necessary for achievement of the set temperature without fuel and with fuel. It is visible that at the temperatures above 700°C the reactor with fuel consumes less electric power, than the same reactor without fuel. It indicates the existence of a heat source besides the electro heater.

At achieving the temperature of 1200°C the power required for maintaining this temperature without fuel is 1100 W. With the fuel the required power was about 650 W, and only 300-330 W one hour after. It is possible to make COP assessment based on these data. For this it is necessary to consider a difference between processes in the reactor with/without fuel and to take into account an additional thermal emission.

The intensity of heat exchange (the produced power) is defined by a temperature on a border of environments, i.e. the external temperature of the heater. In absence of an internal source of heat, the temperature outside and inside cannot strongly differ from each other. In the presence of an additional thermal emission in the center of reactor, there is a thermal flux directed to outside that leads to an appearance of temperature gradient. Therefore

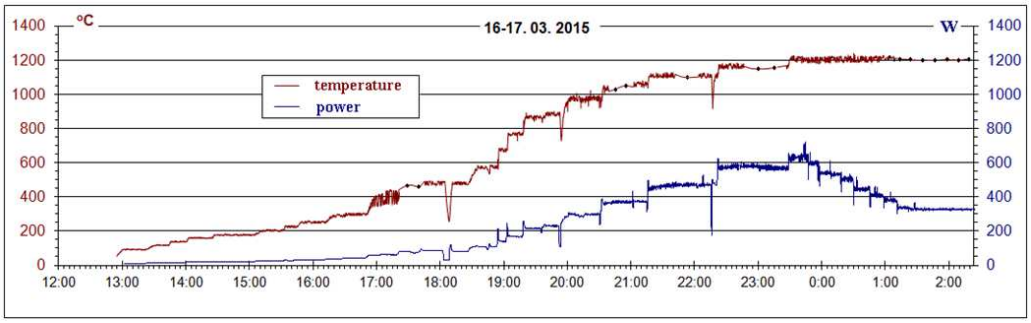


Figure 4. Heating the reactor to a working temperature. The Moscow time (UT+3) is shown on the horizontal scale.

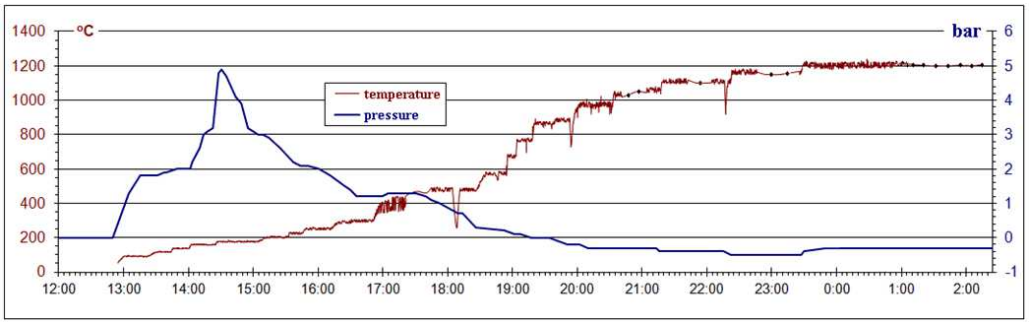


Figure 5. Heating the reactor to a working temperature. Change of pressure during the heating.

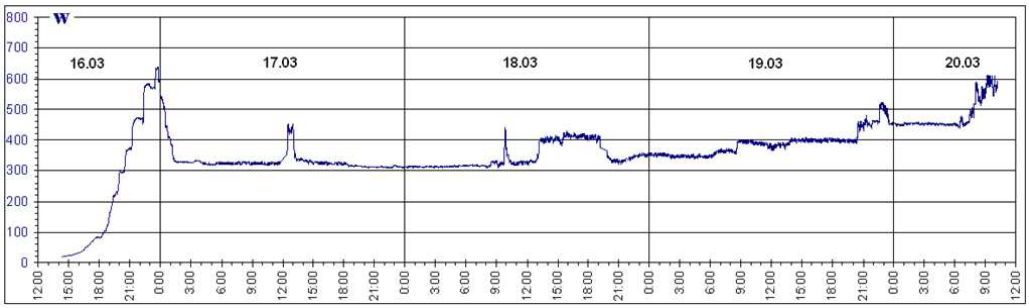


Figure 6. The power of heating during almost 4 days until the heater is burned out. After achieving the temperature of 1200°C at 23:30 on 16.03.2015 this temperature was maintained until 10:50 on 20.03.2015 by automatic adjustment of heater power.

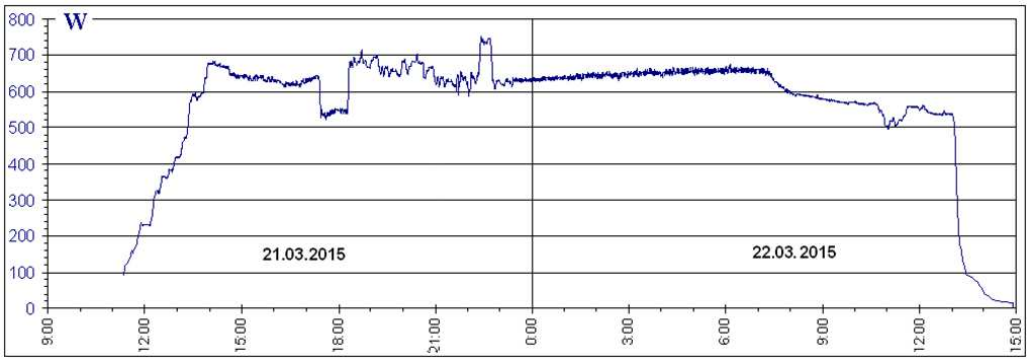


Figure 7. The power consumed by the reactor after it was switched on with a new heater. After achieving the temperature of 1200°C at 13:50 on 21.03.2015 this temperature was supported until 13:00 on 22.03.2015 by automatic adjustment of heater power.

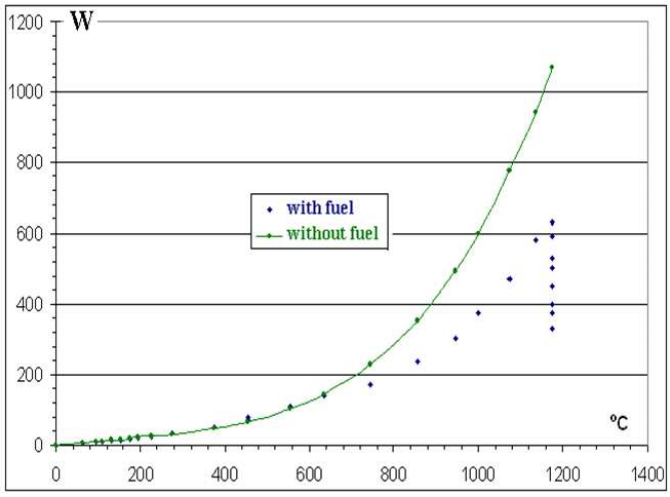


Figure 8. Power necessary for maintaining the set temperature.

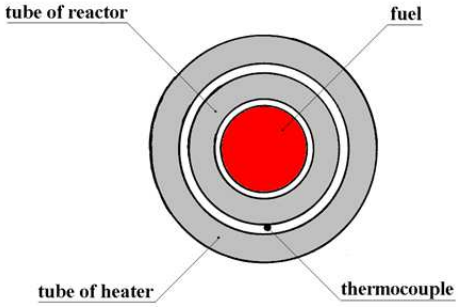


Figure 9. Cross-section of the reactor's central zone.

the temperature measured by the thermocouple on the surface of reactor steel tube (inside the heater's tube) is lower than a real temperature on a heater (outer) surface.

Measurements by an additional thermocouple showed that at the temperature 1200°C on the reactor's (inner) tube the heater (outer) surface temperature (at the first switching) was near 1070°C; reactor was loaded with fuel. Since the dissipated power is defined by the external temperature, the reactor totally produces so much heat as it was required without fuel at the temperature 1070°C (about 800 W). Considering it, COP = 800/330 = 2.4.

After a repeated switching the reactor, the heater surface temperature was 1130°C at the temperature 1200°C on a reactor tube surface. In same way, the reactor produces so much heat as it was required without fuel at temperature 1130°C (about 950 W). The power consumption changed within 550-700 W. Therefore, at repeated switching the COP is about 1.3...1.7.

## VII. Investigations after reactor stop

After stopping and cooling the reactor, the tube was opened, the ceramic inserts and the container with fuel are extracted. It was revealed that the container was well remained. The container and sites of ceramic inserts close to it became covered by a raid of black color (see Fig. 10).

The fuel (see Fig. 11) extracted from the container represents a baked substance of light gray color. It

Figure 10. The container with fuel after extraction from the reactor tube. On each side – ceramic inserts.

differs from initial fuel mix (powder of black color). In optical microscope it is visible that the used fuel has an appearance of baked small droplets of golden color with impurity of gray colored powder (see Fig. 11).

Figure 11. Fuel after extraction from the container.

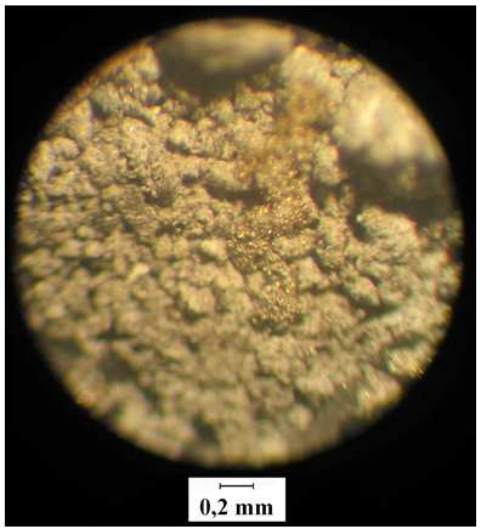


Figure 12. Image of the used fuel at optical microscope.

The images received on the electronic scanning microscope show that nickel in initial fuel mix have an appearance of porous spherical clusters about 10 microns in size. Lithium aluminum hydride has an appearance of flakes with the size from units to hundreds of microns (fig. 13).

In the fuel extracted from the reactor (after operation) we can identify two components: alloyed mass, consisting

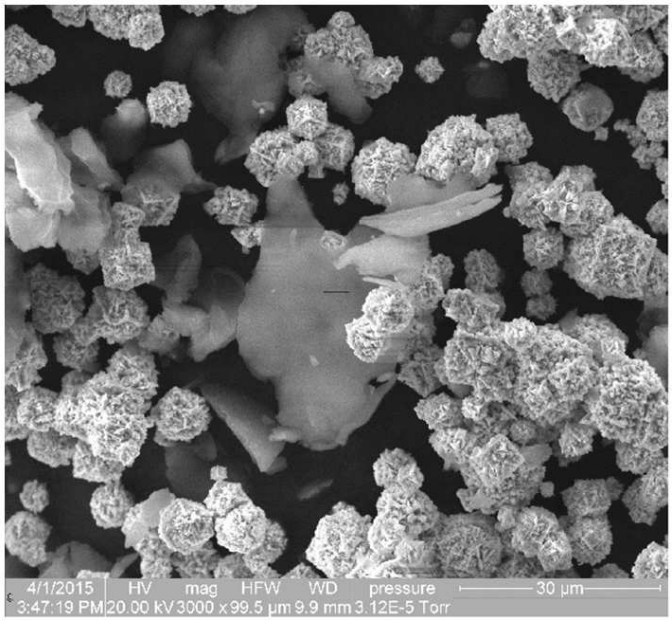


Figure 13. View of the fuel mixture in the electronic scanning microscope before the experiment.

mainly of nickel, and flakes, consisting mainly of aluminum and oxygen (Fig. 14).

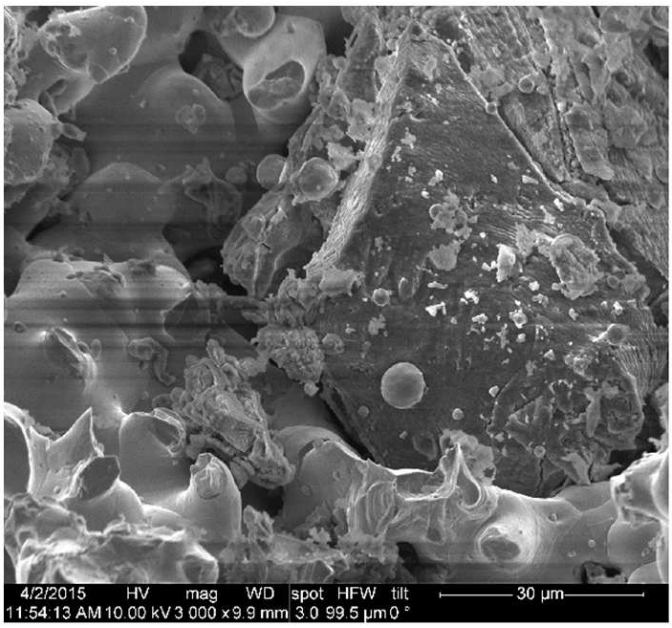


Figure 14. View of the fuel mixture in the electronic scanning microscope after the experiment.

## VIII. Analysis of compositions of initial and used fuel

Investigations of element and isotope compositions of fuel mix are in progress now. The up to now performed analyses did not reveal considerable changes of *isotope* composition of fuel. It is possible to assume that it is related to insufficient duration of this experiment. The Lugano experiment [2], where strong isotope changes were found, was 10 times longer with much higher power.

Investigation of *element* structure with an electronic microscope showed a very strong distinction for different places of test selection. However, two fractions distinctly differ from each other: in one of them an aluminum and oxygen prevail, a nickel prevails in another fraction. The fraction with nickel contains considerably more iron, chrome, silicon, sodium, potassium, titanium and some other elements after reactor operation.

## IX. Conclusions

1. Experiments with devices similar to high-temperature Rossi heat generator loaded by a mixture of Ni and $Li[AlH_4]$ demonstrated that these devices produce more energy than they consume at the temperature about 1100°C and more.

2. The second version of the rector worked continuously for more than 3 days, thereby producing more than twice as much as the applied electrical energy. More than 40 kWh or 150MJ were produced in excess of the electrical energy consumed. This amount of energy could be obtained by burning several liters of oil products.

3. The pressure in the reactor chamber during a slow heating was relatively low.

4. There was no ionized radiation above the background level observed while operating the reactor.

5. Preliminary conclusions from the analysis of fuel element and isotope composition indicated a minor change of isotope structure and an appearance of new elements in the used fuel.

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## References

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[2] G. Levi, E. Foschi, B. Höistad, R.Pettersson, L. Tegnér, H.Essén. Observation of abundant heat production from a reactor device and of isotopic changes in the fuel. http://www.sifferkoll.se/sifferkoll/wp-content/uploads/2014/10/LuganoReportSubmit.pdf.