Isotopic and Elemental Composition of Substance in Nickel-Hydrogen Heat Generators

K.A. Alabin[1], S.N. Andreev[1], S.N. Zabavin[3],
A.G. Parkhomov[3], A.G. Sobolev[2] T.R. Timerbulatov[3]

[1]Prokhorov General Physics Institute, Russian Academy of Sciences
[2]Lebedev Physical Institute, Russian Academy of Sciences
[3]R & D laboratory K.I.T.

At the present time, many devices have been created that produce energy comparable to energy release in nuclear reactions, but not accompanied by harmful radiation and radioactivity.

The nature of this surprising effect remains unclear. The study of elemental and isotopic changes in the operation of reactors is of paramount importance for solving this problem.

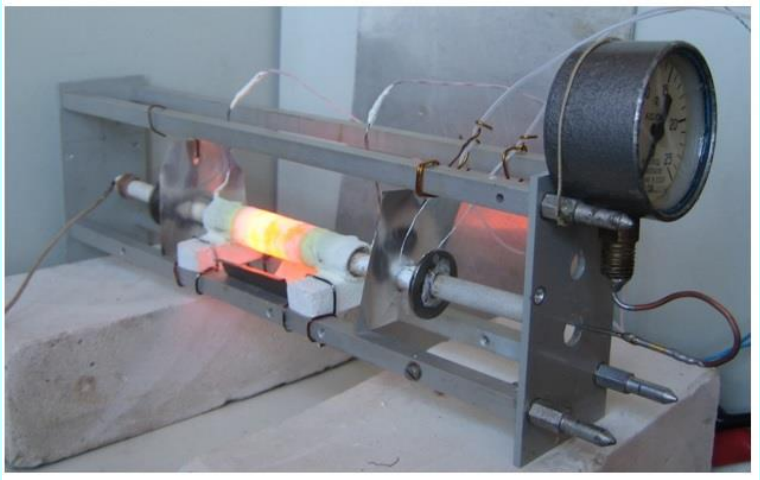
Estimates show that if the anomalous heat release is really associated with changes at the nuclear level, the appearance of nuclides originally absent from the fuel can be detected with excess energy of about 1 MJ per gram of fuel.

To reliably detect changes in the ratios of isotopes in elements that originally form part of the fuel, excess energy is required to exceed 100 MJ / g. It is natural that even a thorough analysis of the fuel of reactors with insufficient development of excess energy does not reveal any changes.

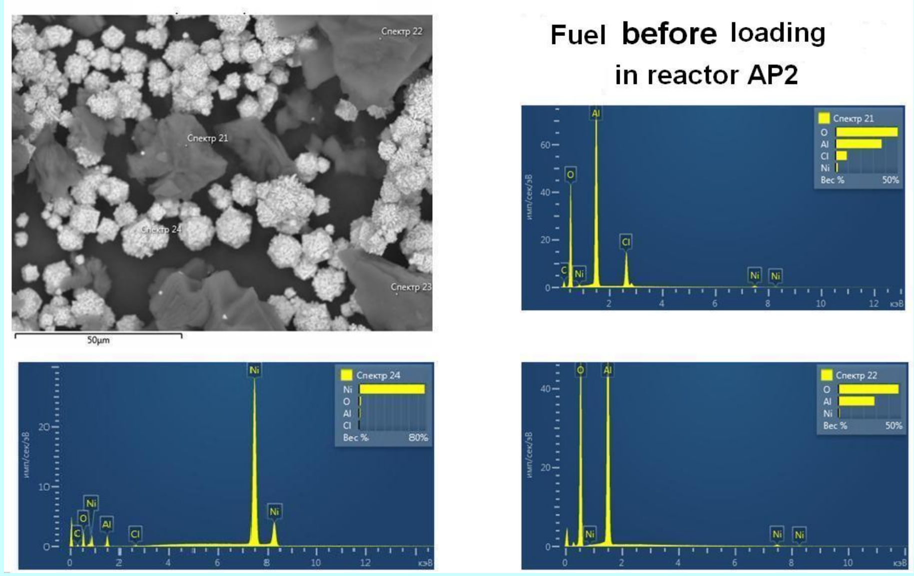
Excess energy in the high-temperature heat-generator of Rossi was 5800 MJ / g. This is quite sufficient for radical changes in the isotopic composition of both nickel and lithium.

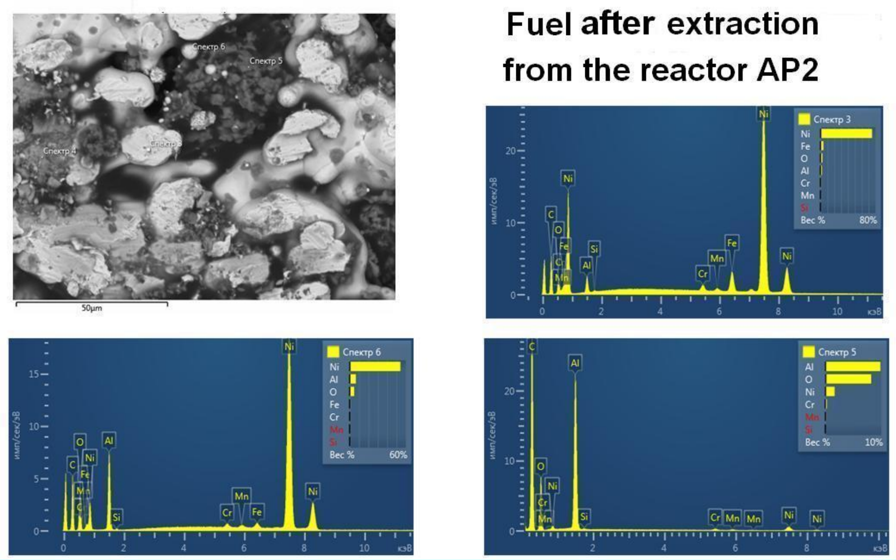
This report provides information on the results of the analysis of changes in fuel and in structural materials that occurred in several nickel-hydrogen reactors created by our team.

Reactor AP2



Reactor was charged with a fuel mixture of 640 mg Ni + 60 mg $LiAlH_4$. It worked on March 16-22, 2015, producing about 150 MJ of excess heat.



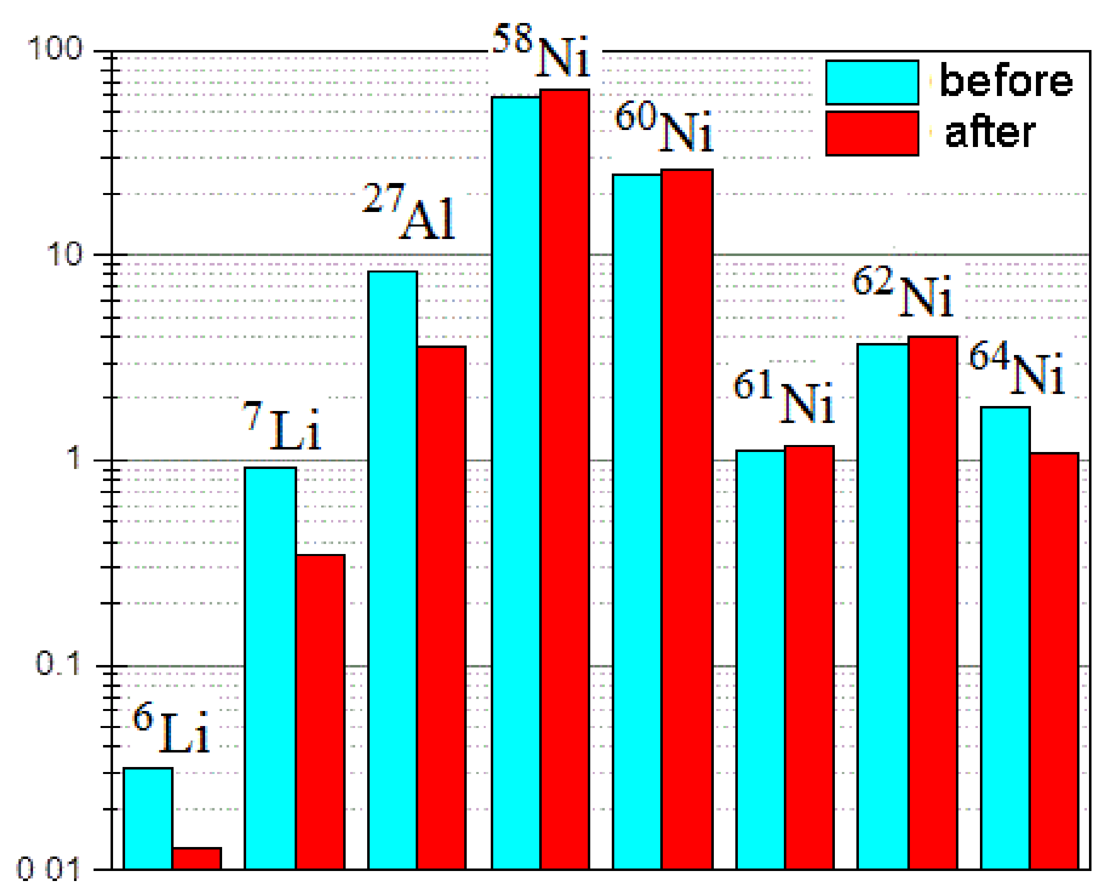


Elemental composition analysis using an electronic scanning microscope
(Prokhorov General Physics Institute, Russian Academy of Sciences)

Elemental composition of fuel before and after work in the reactor AP2, determined by a laser atomic-emission spectrometer (Kurnakov Institute of General and Inorganic Chemistry RAS)

Atomic %

Element	before	after	after/before
B	0,0343	0,0362	1,054
C	3,8231	8,2196	2,150
O	35,0812	46,8706	1,336
F	0,005	0,0111	2,212
Na	0,031	0,1632	5,266
Mg	0,0034	0,0212	6,246
Al	20,2859	18,8544	0,929
Si	0,2505	2,3906	9,543
P	0,0026	0,0041	1,574
S	0,0056	0,0084	1,501
Cl	0,1752	0,0520	0,297
K	0,0113	0,3951	34,961
Ca	0,01	0,0363	3,628
Ti	0,0009	0,0096	10,691
V	0,0009	0,0093	10,323
Cr	0,0358	1,5922	44,475
Mn	3,6826	0,3247	0,088
Fe	0,1375	0,2042	1,485
Co	0,0014	0,0012	0,869
Ni	36,4072	20,7873	0,571
Cu	0,0074	0,0048	0,643
Zn	0,0073	0,0018	0,242
sum	100,0	100,0	



Isotopic composition of fuel before and after work in reactor AP2. The analysis is made by ICP-MS in Vernadsky Institute of Geochemistry and Analytical Chemistry RAS

ICP-MS Isotopic analysis of fuel at the AP2 reactor

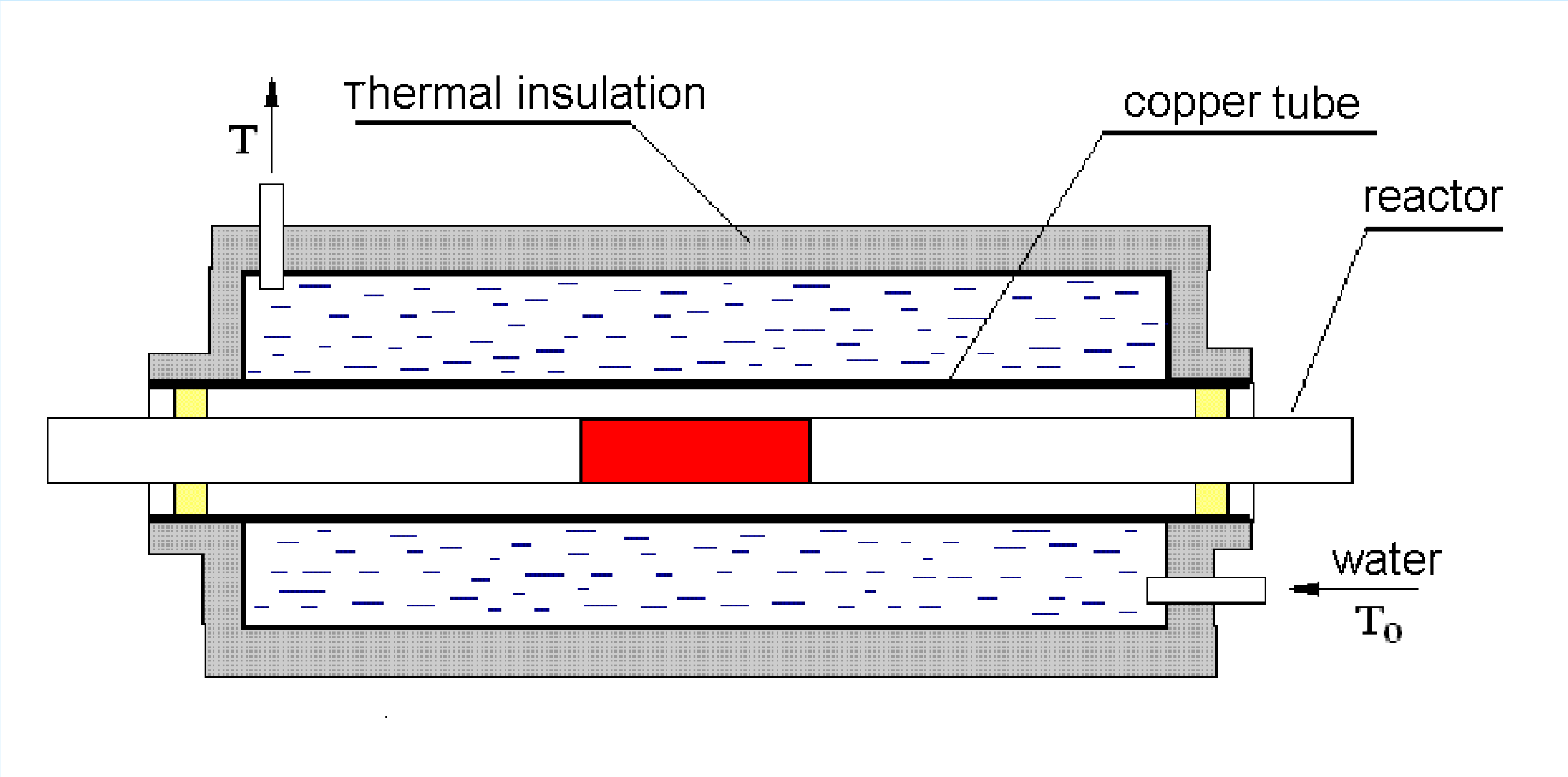
Vernadsky Institute

%	^{6}Li	^{7}Li		^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
before	7,4	92,6		64,0	26,4	1,2	4,0	4,4
after	7,9	92,1		65,0	27,1	1,2	4,1	2,6
nature	7,5	92,5		68,3	26,1	1,13	3,59	0,91

Uppsala University, Sweden

%	^{6}Li	^{7}Li		^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
before	7,4	92,6		68,1	26,2	1,14	3,63	0,93
after	15,4	84,6		63,4	27,6	1,3	5,2	2,5
nature	7,6	92,4		68,0	26,2	1,14	3,71	0,93

Design of a water flow calorimeter



Heat dissipation power W = c (dm /dt) (T-To) (1 + α)

c *is the specific heat of water,*

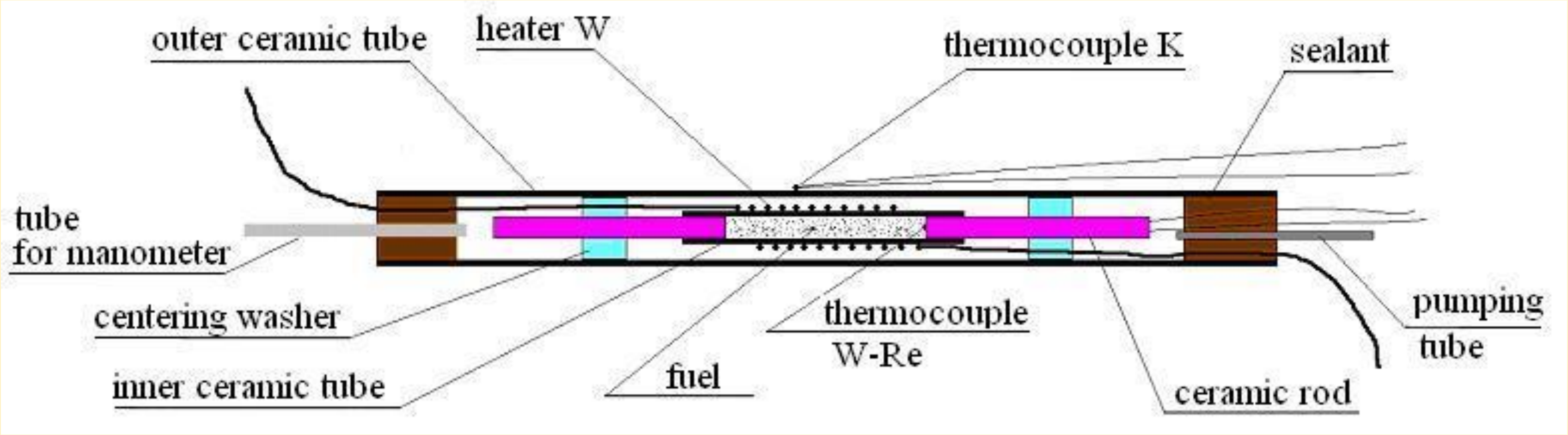
(dm /dt) *is the mass of water flowing per second,*

α - *correction for heat loss,*

T_o *is the temperature at the entrance to the calorimeter,*

T *is the outlet temperature.*

Design of reactors tested in a water flow calorimeter



One of reactors tested in conjunction with water flow calorimeter "Protok-6" worked continuously from April 11 to May 29, 2016, with excess heat output from 20 to 65 watts. The integrated excess energy in this reactor is about 100 MJ.

This reactor had a heater of tungsten wire, located inside of sealed ceramic pipe. The fuel (1.8 g of nickel powder mixed with 0.2 g of lithium aluminum hydride) was in a ceramic tube wrapped in a tungsten heater.

Reactor "Protok-6" after destruction

After opening the reactor, it was found that the inner surface of the outer tube near the heater was covered with a gray, hilly, glassy coating. Fuel has became to vitreous mass with impregnations of metal balls about 0.1 mm in size. Several balls had diameter of up to 1 mm. At the ends of the filling, the fuel took the form of a sintered mass containing small metal balls. In addition, a powder was formed, one of whose fractions had ferromagnetic properties.

The initial fuel mixture, the metal ball from the spent fuel, the fuel at the edge of the core, the formed powder, the coating on the inner surface of the outer tube were subjected to ICP-MS analysis in Vernadsky Institute

Relative content of nuclides (atomic%) in fuel and near the core of the reactor "Protok-6" before and after reactor operation.
Nuclides with a content > 0.1% are shown.

Before reactor operation						After reactor operation									
initial fuel		ceramics		W wire		metal ball in spent fuel		coating on inner surface of outer tube		substance appeared between inner and outer tubes			
7Li	0,74	23Na	7,03	23Na	5,37	11B	0,19	23Na	1,56	11B	0,44	75As	0,43
23Na	1,90	24Mg	1,61	24Mg	0,25	23Na	5,07	24Mg	1,16	23Na	14,70	76Ge,Se	0,16
24Mg	0,12	25Mg	0,23	27Al	0,31	24Mg	0,21	25Mg	0,15	24Mg	0,82	77Se	0,17
27Al	3,63	26Mg	0,28	29Si	1,88	27Al	0,22	26Mg	0,17	26Mg	0,15	79Br	0,97
29Si	1,04	27Al	65,05	31P	0,18	29Si	3,94	27Al	0,23	27Al	0,92	81Br	1,03
39K	1,60	29Si	1,55	39K	6,09	31P	0,14	29Si	0,77	29Si	9,37	90Zr	0,16
44Ca	0,28	31P	0,16	44Ca	1,06	39K	3,51	39K	0,86	31P	0,32	115InSn	0,26
45Sc	0,22	39K	8,36	45Sc	0,80	43Ca	0,14	44Ca	0,71	39K	9,89	120Sn,Te	0,12
51V	0,68	44Ca	0,94	54Cr	0,40	44Ca	1,08	45Sc	0,24	43Ca	0,35	127I	0,15
53Cr	0,22	45Sc	0,61	56Fe	10,46	45Sc	0,91	51V	0,10	44Ca	2,15	138Ba,La,Ce	0,36
55Mn	0,17	48Ti,Ca	0,15	182W	18,50	51V	1,56	52Cr	0,57	45Sc	1,95	140Ce	6,54
56Fe	0,99	54Cr	0,41	183W	9,52	52Cr	0,14	53Cr	0,10	48Ti,Ca	0,13	142Ce,Nd	0,85
58Fe,Ni	55,91	56Fe	10,00	184W	21,48	53Cr	0,51	54Cr	1,17	51V	6,08	182W	3,50
60Ni	23,58	58Fe, Ni	0,15	186W,Os	21,29	54Cr	0,46	56Fe	19,10	52Cr	0,48	183W	1,77
61Ni	1,10	89Y	0,25	200Hg	0,20	55Mn	0,14	57Fe	0,45	53Cr	2,07	184W,Os	4,09
62Ni	3,63	90Zr	0,44	202Hg	0,21	56Fe	7,36	58Fe,Ni	32,31	54Cr	0,61	186W,Os	3,82
64Ni,Zn	1,24	92Sr,Mo	0,16	198Hg	0,21	57Fe	0,18	59Co	0,40	55Mn	0,28	206Pb	0,21
66Zn	0,16	94Sr,Mo	0,16			58Fe,Ni	45,07	60Ni	13,93	56Fe	6,48	207Pb	0,19
68Zn	0,12	138 Ba,Ce	0,33			60Ni	19,81	61Ni	0,68	57Fe	0,18	208Pb	0,49
79Br	0,13	206Pb	0,13			61Ni	0,86	62Ni	2,10	58Fe,Ni	8,25		
81Br	0,12	208Pb	0,29			62Ni	2,97	64Ni,Zn	5,06	60Ni	3,30		
138Ba,La,Ce	0,25					63Cu	0,14	66Zn	2,88	61Ni	0,15		
206Pb	0,32					64Ni,Zn	1,62	67Zn	0,47	62Ni	0,54		
207Pb	0,25					66Zn	0,52	68Zn	2,02	63Cu	0,17		
208Pb	0,69					68Zn	0,40	88Sr	0,11	64Ni,Zn	1,48		
						75As	0,15	115InSn	0,13	66Zn	0,81		
						79Br	0,35	140Ce	0,37	67Zn	0,15		
						81Br	0,36	182W	2,81	68Zn	0,63		
						138Ba,La,Ce	0,14	183W	1,54				
						184W,Os	0,12	184W,Os	3,52				
						208Pb	0,17	186W,Os	3,24				

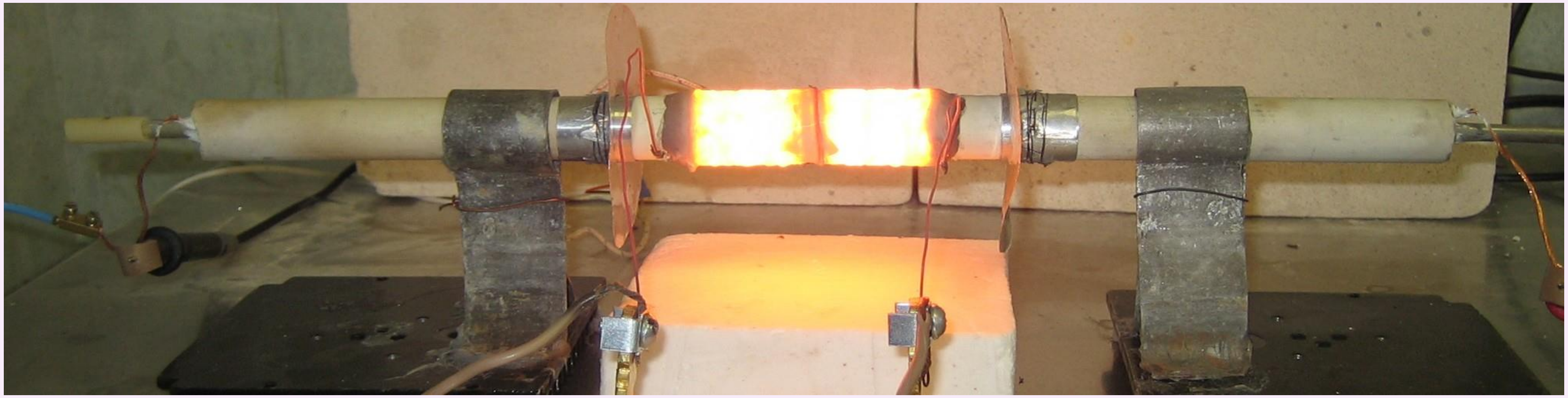
Obvious result of isotopic analysis is the increase in the content of many nuclides in comparison with their content in the initial fuel and structural materials. The content of boron, iron, gallium, cerium, zirconium, strontium, bismuth increased greatly. The most significant anomalies are found in the powder accumulated in the space between the inner and outer tubes. Especially many appeared ^{140}Ce: 6.3% (in the initial fuel <0.0001%). A significant amount of tungsten found in the samples after being in the reactor is probably due to the migration of this element from the incandescent tungsten helix

Ratio of nickel isotopes in the fuel and near the core of the "Protok-6" reactor before and after the reactor operation.

%	^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
initial fuel	65,78	27,74	1,29	4,28	0,91
metal ball	65,00	28,57	1,24	4,29	0,91
fual at edge	65,58	27,88	1,27	4,36	0,91
coating on ceramics	65,32	28,16	1,37	4,24	0,91
powder between tubes	66,74	26,71	1,23	4,41	0,91
natural ratio	68,27	26,1	1,13	3,59	0,91

Since the data on ^{64}Ni is unreliable due to the uncontrolled additive ^{64}Zn, when preparing the table for the ^{64}Ni fraction, the natural value was assigned

Reactor VV3



Reactor VV3 differs from the "Protok 6" reactor with a different heater design and the absence of a calorimeter. A mixture of nickel powder with lithium aluminum hydride weighing 1.5 g was used as fuel. The fuel contained pieces of tungsten wire with a total mass of 0.77 g. The reactor operated from June 14 to July 24, 2016, producing excess power up to 330 W. A total of 790 MJ of excess heat was generated.

Fuel after operation in the VV3 reactor

ICP-MS analysis of fuel was done In Vernadsky Institute, with separate analyzes of the surface and deeper layers. Partially, the results of the analysis are shown in Table 4. In addition to the data for the samples recovered from the reactor after its operation, information on the content of isotopes in the initial fuel, including tungsten wires embedded in it, is given.

Before		After					
Initial fuel		Surface		Surface		Deep layer	
23Na	2,61	10B	0,15	75As	0,17	10B	0,14
24Mg	0,15	11B	0,67	79Br	0,11	11B	0,66
27Al	2,93	24Mg	1,50	81Br	0,21	23Na	3,72
29Si	1,22	25Mg	0,12	88Sr	0,23	27Al	1,02
39K	2,52	26Mg	0,27	90Zr	0,20	28Si	0,25
44Ca	0,44	27Al	1,14	107Ag	1,13	51V	2,14
45Sc	0,34	28Si	0,54	109Ag	2,01	52Cr	0,30
51V	0,55	44Ca	0,16	127I	0,43	53Cr	0,73
53Cr	0,18	45Sc	0,18	140Ce	0,72	54Cr	0,21
55Mn	0,14	51V	2,41	182W	3,34	56Fe	2,55
56Fe	2,92	52Cr	0,31	183W	1,61	58Fe,Ni	44,47
58Fe,Ni	45,09	53Cr	0,81	184W,Os	3,39	60Ni	18,23
60Ni	19,01	56Fe	0,42	185Re	0,26	61Ni	0,87
61Ni	0,88	58Fe,Ni	46,08	186W,Os	2,91	62Ni	2,83
62Ni	2,93	60Ni	19,34	187Re,Os	0,60	64Ni,Zn	0,87
64Ni,Zn	1,00	61Ni	0,96	206Pb	0,18	75As	0,12
66Zn	0,13	62Ni	3,02	207Pb	0,13	79Br	0,19
68Zn	0,10	63Cu	0,39	208Pb	0,34	81Br	0,19
79Br	0,10	64Ni,Zn	1,31			90Zr	0,39
7Li	0,60	65Cu	0,16			92Sr,Mo	0,14
81Br	0,10	66Zn	0,37			94Sr,Mo	0,16
138Ba,La,Ce	0,20	68Zn	0,20			107Ag	1,37
182W	3,73					109Ag	1,39
183W	1,92					140Ce	0,78
184W	4,33					142Ce,Nd	0,10
186W,Os	4,29					182W	3,49
206Pb	0,26					183W	1,90
207Pb	0,20					184W,Os	4,17
208Pb	0,56					185Re	0,38
						186W,Os	3,72
						187Re,Os	0,60
						208Pb	0,17

The content of nuclides (atomic%) in the fuel of the reactor VV3 before and after the operation of the reactor. Isotopes with a content > 0.1% are shown.

The content of nuclides in fuel as a result of being in the reactor has changed markedly.

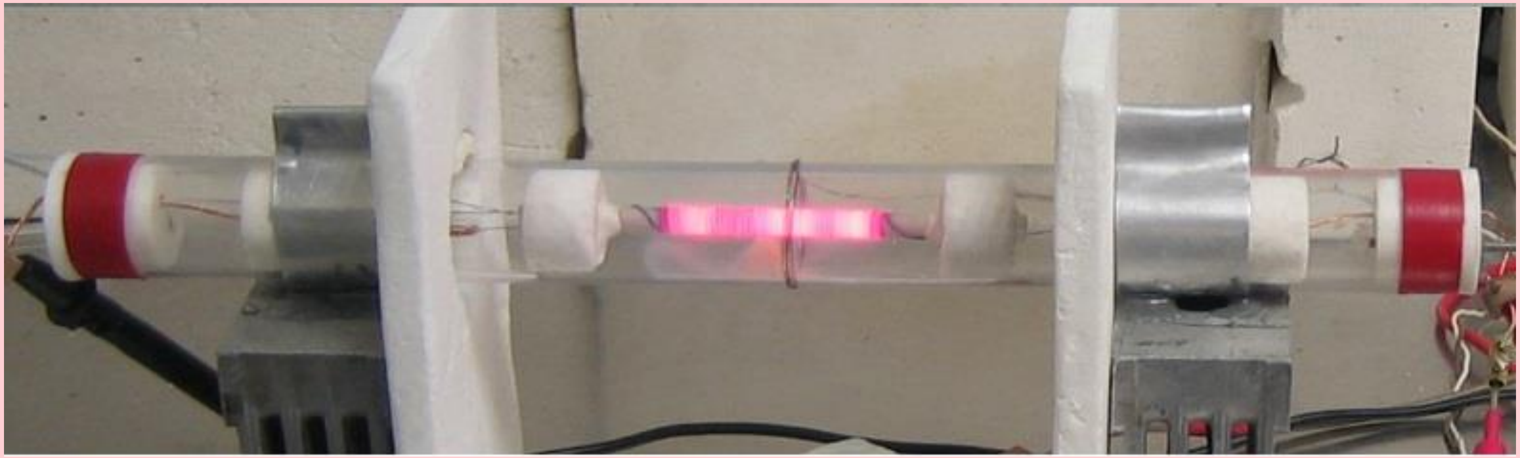
The content of boron, copper, cerium, and silver increased especially.

Ratio of nickel isotopes in fuel VV3 before and after operation of the reactor

%	^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
initial fuel	65,93	27,98	1,19	3,98	0,91
surface	65,79	27,61	1,37	4,31	0,91
deep layer	66,36	27,20	1,29	4,23	0,91
natural ratio	68,27	26,10	1,13	3,59	0,91

Data on the investigated samples, although slightly different from the natural ratio, differ slightly among themselves.

Reactor KV3



Reactor KV3 at the beginning of work

The KV3 reactor operated from December 20, 2016 until January 31, 2017, with an excess power of 100-200 watts. Integral excess heat generation is about 400 MJ.

Fuel: a nickel powder weighing 1.8 grams without admixture of lithium aluminum hydride. Saturation with hydrogen was carried out by aging in hydrogen gas. The reactor had not a ceramic but a quartz outer tube. The heater was made of tungsten-rhenium alloy.

Reactor KV3 opened after completion of work.

The content of nuclides (atomic%) in the fuel and near the core of the KV3 reactor before and after the reactor operation. Isotopes with a content > 0.1% are shown. ICP-MS analysis is made in Vernadsky Institute

Before						After							
Initial fuel		Ceramic		Heater wire		Fuel central zone		Ceramic		Ceramic		Substance appeared between inner and outer tubes	
23Na	0,33	27Al	88,15	23Na	0,47	23Na	0,13	11B	0,13	64Ni,Zn	0,22	23Na	5,53
39K	0,38	23Na	1,98	29Si	0,27	31P	0,11	23Na	15,61	66Zn	0,11	24Mg	0,50
56Fe	0,45	24Mg	0,82	39K	0,40	39K	0,14	24Mg	1,06	76Ge,Se	0,20	27Al	0,32
58Fe, Ni	64,49	25Mg	0,12	44Ca	0,12	56Fe	0,23	25Mg	0,13	88Sr	0,21	29Si	1,42
60Ni	27,63	26Mg	0,14	56Fe	0,21	58Fe, Ni	65,39	26Mg	0,24	89Y	0,22	31P	0,16
61Ni	1,18	29Si	0,37	58Fe,Ni	0,12	60Ni	26,15	27Al	6,05	90Zr	0,42	39K	6,93
62Ni	3,88	39K	2,10	182W	20,24	61Ni	1,18	29Si	4,26	92Sr,Mo	0,22	44Ca	0,88
64Ni,Zn	1,21	44Ca	0,21	183W	11,02	62Ni	3,99	39K	15,26	94Sr,Mo	0,17	45Sc	0,82
		47Ti	0,88	184W,Os	24,39	63Cu	0,84	43Ca	0,26	109Ag	0,10	54Cr	0,26
		48Ti,Ca	0,18	185Re	6,97	64Ni,Zn	1,14	44Ca	3,15	127 I	0,16	56Fe	7,04
		54Cr	0,14	186W,Os	22,23	65Cu	0,42	45Sc	2,04	138 Ba,Ce	0,39	58Fe, Ni	1,80
		56Fe	3,17	187Re,Os	11,85			48Ti,Ca	0,23	182W	4,32	60Ni	0,74
		58Fe, Ni	0,28	198Hg,Pt	0,12			51V	0,22	183W	2,35	62Ni	0,10
		60Ni	0,11	200Hg	0,14			54Cr	0,96	184W	5,01	63Cu	0,13
		89Y	0,13	202Hg	0,13			55Mn	0,10	185Re	5,95	64Ni,Zn	0,15
		138 Ba,Ce	0,17	208Pb	0,18			56Fe	21,14	186W,Os	4,77	182W	18,29
								57Fe	0,15	203Tl	0,15	183W	10,44
								58Fe, Ni	0,91	206Pb	0,15	184W	21,36
								60Ni	0,37	207Pb	0,15	186W,Os	20,90
								63Cu	0,14	208Pb	0,40	198Hg	0,17
												200Hg	0,20
												202Hg	0,18
												208Pb	0,15

Comparing fuel before and after work in the reactor, you can see a decrease in the content of sodium, potassium and iron. **The appearance of a significant amount of copper is noteworthy.**

In space between inner and outer tubes a lot of tungsten, as well as iron, sodium, potassium, nickel, silicon, calcium, scandium and a number of other elements appeared.

	before	after	after/before		before	after	after/before
10B	0,0008	0,0318	72,5	109Ag	0,0071	0,1020	24,8
11B	0,0054	0,1277	40,7	113Cd,In	0,0001	0,0009	23,7
23Na	1,9837	15,6088	13,7	114Cd,Sn	0,0005	0,0064	20,7
29Si	0,3709	4,2603	19,9	112CdSn	0,0004	0,0037	15,8
39K	2,1043	15,2572	12,6	116Cd,Sn	0,0022	0,0275	22,2
43Ca	0,0158	0,2638	29,1	117Sn	0,0011	0,0129	20,7
44Ca	0,2123	3,1461	25,7	118Sn	0,0024	0,0422	31,1
45Sc	0,0507	2,0384	69,8	120Sn,Te	0,0034	0,0670	33,9
46Ti,Ca	0,0074	0,0836	19,6	122Te	0,0007	0,0101	26,1
51V	0,0028	0,2151	135	119Sn	0,0014	0,0165	20,3
53Cr	0,0057	0,0753	23,1	127 I	0,0062	0,1589	44,6
54Cr	0,1358	0,9584	12,2	128Te	0,0002	0,0046	39,5
56Fe	3,1726	21,1380	11,6	124Te	0,0008	0,0092	19,7
59Co	0,0006	0,0055	16,4	130Te	0,0006	0,0101	29,0
63Cu	0,0175	0,1387	13,8	134	0,0059	0,0340	10,1
64Ni,Zn	0,0186	0,2224	20,8	141Pr	0,0006	0,0037	10,5
65Cu	0,0085	0,0808	16,5	176	0,0011	0,0073	11,2
66Zn	0,0099	0,1102	19,3	178Hf	0,0050	0,0331	11,4
67 Zn	0,0014	0,0211	26,0	180W	0,0067	0,0551	14,4
68Zn	0,0080	0,0808	17,5	182W	0,0076	4,3168	985
70Ge	0,0004	0,0028	11,8	183W	0,0035	2,3489	1166
72Ge	0,0001	0,0037	47,2	184W	0,0076	5,0087	1143
75As	0,0001	0,0138	177	185Re	0,0006	5,9469	17053
76Ge,Se	0,0115	0,1976	29,8	186W,Os	0,0089	4,7748	933
77Se	0,0001	0,0055	143	198Hg	0,0001	0,0321	414
78Se,Kr	0,0028	0,0542	34,1	199Hg	0,0007	0,0248	58,1
79Br	0,0028	0,0560	35,3	200Hg	0,0004	0,0560	241
81Br	0,0040	0,0790	34,0	202Hg	0,0005	0,0606	224
82Kr	0,0001	0,0009	11,8	203Tl	0,0015	0,1498	176
83Kr	0,0001	0,0009	23,7	204Pb,Hg	0,0010	0,0101	17,4
84Kr,Sr	0,0009	0,0083	15,2	206Pb	0,0242	0,1488	10,7
92Sr,Mo	0,0315	0,2160	11,9	207Pb	0,0163	0,1525	16,2
107Ag	0,0067	0,0863	22,5	208Pb	0,0449	0,4011	15,5

Relative content of nuclides (atomic%) in the ceramic tube before and after the operation of the KV3 reactor. Nuclides are shown whose content has increased more than 10 times.

In addition to tungsten and rhenium, the appearance of which can be explained by migration from the helix of the heater, the content of boron has greatly increased in the ceramic tube, as well as nuclides with atomic masses of 43-53, 64-83, 107-130, 198-208.

The ratio of nickel isotopes in fuel and near the core of the KV3 reactor before and after reactor operation.

%	^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
Initial fuel	65,93	27,98	1,19	3,98	0,91
Fuel after work	65,74	28,17	1,20	3,98	0,91
Substance between tubes	66,66	27,33	1,30	3,79	0,91
Ceramics	67,65	27,37	0,82	3,26	0,91
Natural ratio	68,27	26,10	1,13	3,59	0,91

The isotopic composition of nickel in fuel before and after work in the reactor remained practically unchanged. Some differences are noticeable in the results obtained for the ceramic tube and the substance between the tubes. But these results can not be considered accurate, since the concentration of nickel in the samples studied is not high enough for reliable analysis.

CONCLUSIONS

The analysis of the isotopic and elemental composition of the substance in four nickel-hydrogen reactors of various designs with the development of excess energy from 100 to 790 MJ was done. Not only the changes in fuel, but also in materials adjacent to the core have been investigated. In addition, the composition of the substance accumulating in the cavity of the reactor near the core has been studied.

There were no significant changes in the isotopic composition of nickel and lithium, except for the analysis of the fuel of the AP2 reactor at Uppsala University (Sweden).

Significant increase in the concentration of impurities in a number of nuclides has been observed not only in fuel, but also in structural elements adjacent to the active zones of the reactors. In addition to tungsten and rhenium, the appearance of which can be explained by migration from the helix of the heater, the content of boron increases greatly in them, as well as nuclides with atomic masses of 43-53, 64-83, 107-130, 198-208.

In substance accumulated in the cavity of the reactor near the core, in addition to tungsten, a lot of iron, sodium, potassium, nickel, silicon, calcium, scandium and a number of other elements accumulated.

References

1.Levi G., Foschi E, Höistad B. 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

2. Parkhomov A.G. Report of the international commission on the test of high-temperature heat generator Rossi. − IJUS, 2014, v.2, № 6, pp. 57-61 (in Russian). http://www.unconv-science.org/pdf/6/parkhomov2-ru.pdf

3. Parkhomov A.G. Nickel-hydrogen reactors created after publication of the report on experiment in Lugano (in Russian). − IJUS, 2016, v.4 № 11, pp.58–62, http://www.unconv-science.org/pdf/11/parkhomov-ru.pdf

4. Alabin K.A., Andreev S.N., Parkhomov A.G. Results of analysis of isotopic and elemental composition of the fuel of nickel-hydrogen reactors. − IJUS, 2015, v. 3, №10, pp. 49-53 (in Russian). http://www.unconv-science.org/pdf/10/alabin-ru.pdf

5. Parkhomov A.G. Investigation of new version of the device similar to high-temperature Rossi heat generator. -IJUS, 8(3), pp. 34-38, 2015. http://www.unconv-science.org/pdf/8/parkhomov-en.pdf

6. Parkhomov A.G. Long-term tests of nickel-hydrogen heat generators in an water flow calorimeter. − IJUS, 2016, v. 4, №12-13, pp. 74-79 (in Russian). http://www.unconv-science.org/pdf/12/parkhomov-ru.pdf