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VALIDITY OF USING $UPuO_2$ VIBROPACK EXPERIMENTAL FUEL PINS IN REACTORS ON FAST AND THERMAL NEUTRONS: FIRST EXPERIMENTS ON CONVERSION OF WEAPONS GRADE PLUTONIUM INTO NUCLEAR FUEL

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Abstract

Extensive scope of scientific and technological work has been carried out in SSC RF RIAR to substantiate usage of vibropack oxide fuel pins in fast and thermal neutron reactors. In fulfilling of the work there have been studied physical-mechanical and technological characteristics of granulated fuel, carried out radiation tests and material science investigations of mock-up, experimental and research fuel pins of BN-type (in BOR-60 and BN-600 reactors) and VVER-1000 type (in SM-2 and MIR reactors). Total quantity of fabricated fuel pins is about 30 000 pieces. In BOR-60 reactor maximum burn-up attained 30% h.à. for regular SA and burnup was of 32,3% h.a. for experimental fuel pins of the dismantled SA. In testing $UPuO_2$ vibropack fuel pins in BN-600 reactor there was attained maximum burn-up of- 10,8% h.a. Post irradiation examinations of fuel pins have revealed, that since the problems both of chemical and thermo-mechanical fuel-cladding interactions were solved, the resource of the fuel pins like these would only depend on the choice of cladding material. Vibropack fuel pins, containing $UPuO_2$ under conditions of MIR reactor attained burn-up more than 30 MW day/kg U both under nominal operation and under load-following modes.

The experience in designing, manufacturing and operating the facilities on fabrication of granulated uranium and MOX fuel and fuel pins is gained. There is created the data bank and calculation codes, describing vibropack fuel pin behavior under different operation modes.

According to the Concept of RF Minatom on recovery of surplus weapon-grade plutonium, resulted from disarmament, the State Scientific Center of Russian Federation RIAR (Dimitrovgrad) has begun a practical realization of the technology on conversion of metal weapon-grade plutonium into mixed uranium - plutonium oxide fuel. There has been carried out processing and is obtained granulated $UPuO_2$ fuel for BOR - 60, BN - 600 reactors and experimental batches of granulated fuel for mock-up and experimental fuel pins of VVER type, which are intended for testing in SM and MIR reactors.

I. INTRODUCTION

The main fuel kind of energetic facilities for the last 50 years is oxide fuel. It is unlikely to be substituted for either metallic fuel or nitride one in the near future. That's why the technologies, enabling to increase greatly oxide fuel possibilities and to upgrade considerably technicoeconomic factors of fuel cycle as a whole as well as taking into account up-to-date requirements to the process safety and ecological compatibility are of special interest.

For the last 25 years SSC RF RIAR has been carrying out the complex investigations to validate the possibility of implementing short close fuel cycle for nuclear reactors. In contrast to the conventional aqueous method fuel reprocessing SSC RF RIAR activities are based on the principles of «dry»technology, including:

- pyroelectrochemical methods of reprocessing high-active nuclear fuel in the molten salts followed by obtaining granulate, which is suitable for fuel pin fabrication by vibropacking;
- vibropacking technology for fabricating fuel pins of granulated fuel;
- automated remote-control processes to produce granulated fuel, fuel pins and SA.

By the moment the first stage of scientific-research activities on development and experimental validity of fast reactor fuel pins, containing vibropack MOX fuel has largely been completed. Developed fuel pin design and carried out comprehensive study on radiated stability of vibropack fuel and the pins, containing this fuel, as well as worked out automated remote-controlled technology for fuel pin fabrication perfectly meet the requirements to the closed fuel cycle concept and show high technicoeconomic and operational characteristic. There is gained the experience in designing, manufacturing and operating the facilities for the production of granulated uranium and uranium plutonium oxide fuel as well as fuel pins. There is created the data bank and calculation codes. Since 1981 BOR-60 Core has been used vibropack $UPuO_2$ fuel. At present there is attained maximum in the world burnup of - 30,3 % for regular design SA, and -32,3 % for individual experimental fuel pins. By pyroelectrochemical way there has been reprocessed about 10 kg of weapon grade plutonium, from which 16 SA have been manufactured and 12 SA have been tested in BOR-60 reactor. In BN-600 reactor 6 SA with $UPuO_2$ fuel have been tested successfully up to the burnup of 9,6 % (maximum burnup for individual fuel pins ~10,8 %). The report presented the main results to substantiate vibropack oxide fuel pin serviceability for fast and thermal reactors.

2. Technology of vibropack fuel pin fabrication

Vibropacking technology is always considered as the way of fabricating fuel column, which allows one to cut substantially costs for nuclear reactor fuel pin fabrication and to improve fuel pin operational performance. The main merits of the vibropacking technology and vibropack fuel pins are the following:

- simplicity and reliability of the technologic process attributed to less the number of technologic and check operations. This fact simplify automation and remote control of the process, therefore the vibropacking technology can be employed to make fuel pins of recovered fuel in the shielded hot cells;
- the possibility of fabricating fuel column , having easily variable parameters and on the basis of multicomponent compositions;
- the possibility of using any kind granulate: both of homogeneous composition and of mechanical blend;
- less thermal-mechanical fuel effect on the cladding in comparison with pellet fuel
- diminished requirements to the inner diameter of fuel pin claddings.

Vibropacking consists in creating dense packing of the particles for determined granulometric composition powder under the effect of mechanical vibrations. Vibration application makes it possible to impart quasiliquid properties to a dispersive powder medium. At that fuel particles are becoming movable and able to form optimum packed structure in accordance with the particles size and composition.

For the particles of irregular form there is usually used the granulate of polydispersive composition, allowing one to attain necessary smear density value, which is determined as the ratio of $UPuO_2$ granulate full mass to its volume. Application of optimized composition enables to orient to the planned final smear density as early as the fuel portion preparation stage. As a result of vibropacking the fuel column smear density for fast reactor fuel pins is 9,0 ÷9,4 g/ñm^3. For comparison, «smear» density, in other words the one with the allowance for clearance and pellet central hole, of pelletized fuel column is 8,5-8,6 g/ñm^3.

Filling and vibropacking technology provide fuel column smear density and plutonium distribution along the axis within the limits of not more than ±5 %of the nominal level.

To correct O/M ratio and eliminate the influence of technologic impurities, metal uranium granules as a getter are introduced in the granulated fuel at the portion preparation stage. The form of metal uranium getter particle is close to the spherical one with the maximum diameter up to 100 mcm. In exercising the technology there is provided the evenness of getter distribution over the fuel column length in the range of ±5 %. As a result of complex investigations, which included out-pile and in-pile tests (BOR-60, BN-350, BN-600), and postirradiation material science examinations there was upgraded getter contents with the allowance both for thermodynamic characteristic and for the necessity of attaining the required hypostoichiometric fuel **O/M** ratio.

The possibility of fabricating fuel pins by vibropacking is shown in two versions: manual - in the glove boxes and remote - in the shielded cells (Table2.1). Semi-industrial technology of fuel pin and SA manufacture for BOR-60, BN-350 and BN-600 reactors under remote conditions was implemented when working at «ORYOL» facility(1977 - 1986, about 300 SA for BOR-60 were manufactured), SIC (1989-1997, 26 SA of BN-800 type were produced) and «Kolibry» mockup facility (1992-1997, 63 fuel pins were manufactured).

Table 2.1

VIBROPACK OXIDE FUEL PIN FABRICATION

Fuel kind	Reactor	SA quantity, pieces	Fuel pin quantity, pieces
$UPuO_2$(RG)	BOR-60	426	15762
$UPuO_2$(RG)	BOR-60	16	592
$UPuO_2$(WG)	BN-350	2	254
UO_2(reg)	BN-350	7	889
UO_2(reg)	BN-600	6	762
$UPuO_2$(WG)	BN-600	6	762
$UPuO_2$(RG)	BN-600	4	508
$UPuO_2$(WG, RG)	Physical Stand	8	1016
UO_2(reg) + PuO_2(irr.)	BOR-60	1	6
UO_2(reg)	BOR-60	235	8695

R.G. - Pu of reactor grade;
W.G. - Pu of weapon grade;
reg. - «regenerated» -product of irradiated fuel reprocessing at RT-1.
irr. «irradiated» - product of BOR-60(24 %) and BN-350 (4.9%) irradiated fuel reprocessing
Total (state at the end of 1998): SA - 731 pieces, fuel pins - 30000 pieces

. At present there are operated two chains of glove boxes to fabricate fuel pins by vibropacking, which are also used for carrying out different experimental programs, as a well as for producing BOR-60 fuel pins and regular loading SA. Operating technological equipment of Semi-Industrial Complex (SIC) exhibited its high reliability. Serviceable production yield was more than 98 %. In fabricating fuel pins manually at the technologic line, located in the shielded glove box (~1300 BN-350 fuel pins, ~300 BN-600 fuel pins, ~9000 BOR-60 fuel pins), the serviceable fuel pins yield was 100 % almost in all the quality parameters, being under check.

At the end of 1998 there was started the program of the weapon grade plutonium recycling by pyroelectrochemical way with simultaneous purification of gallium down to 7 - 10 ppm. About 20 kg of plutonium was reprocessed into MOX fuel, which was used to manufacture 16 SA by vibropacking, and 12 SA are currently being tested in BOR-60 reactor.

3. The results of vibropack MOX fuel tests in BOR-60, BN-350, BN-600

Tests of vibropack MOX fuel pins occurred in BOR-60, BN-600, BN-350 reactors with the aim of substantiating the design and upgrading both technologic and operational parameters. Main parameters of fuel pins for these reactors are presented in table 3.1.

Table 3.1

Main parameters of fuel pins for fast reactors

N	Parameter	Value		
1	Reactor	BOR-60	BN-350	BN-600
2	length of, mm • fuel pin • gas plenum • bottom blanket zone • fuel column • upper blanket zone	 1082 273 150 450 100	 1790 300 400 1060 -	 2400,2440 600 350 950 350
3	Cladding diameter, mm	6.0; 6.9	6.9	6.6
4	Cladding thickness, mm	0.3; 0.4	0.4	0.4
5	Spacer wire dimension , mm • round • ellipsoidal	 1.05 0.6×1.3	 1.05 0.6×1.3	 1.15 0.6×1.3
6	Smear density of fuel column, g/ñm^3	8.3 ÷ 9.5	8.4 ÷ 8.8	8.8 ÷ 9.2
7	Average mass ratio of PuO_2 in granulate, %	15 ÷ 40	20	30
8	Granulate enrichment in ^{235}U, %	45 ÷ 90	10	-
9	Unevenness of distribution over fuel column length, % • of smear density • of plutonium	 ± 5 ± 5	 ± 5 ± 5	 ± 5 ± 5

3.1 Tests of mixed vibropack fuel in BOR-60 reactor

Since the end of 1981 BOR-60 reactor Core has used vibropack MOX fuel. In the last three years recovered uranium dioxide has also been introduced in the reactor fuel cycle. By the moment about 500 SA have already been tested and are currently under test in the reactor. Their main technologic and operational characteristic are given in table 3.2 . The results of complex investigations on fuel pin design optimization exhibited, that the most radical way of improving fuel pin serviceability consists in introducing metal uranium powder as a getter in the fuel column composition. Getter addition of not more than 5 % wt gave an increase in burnup up to 11,5 % h.à. (maximum burnup is 15÷16 % h.à.). The getter content elevation from 5 up to 10 % and the increase of fuel column density enabled to attain burnups of the same depth, when thermal loading and cladding temperature were higher. Histogram, showing attained burnups for SA with getter, is given in Fig. 3.1.

Post irradiation material science examinations of SA verified the information, obtained before for experimental mixed vibropack fuel pins, concerning their behaviour under irradiation: off-gas, the change of cladding OD (outer diameter), formation of fuel column structure, FP s distribution (Zr, Ce, Ru) and etc. Mechanical properties and swelling of the fuel pin claddings were close to those of the experimental fuel pins, containing homogeneous fuel (UPu)Î $_2$, mechanical blend UO_2+PuO_2, and uranium dioxide pellets as well.. It was shown, that in the fuel pins with getter mass ratio more than >3 % there was no sign of physicochemical fuel cladding interaction even at the maximum burnup, thermal loading and cladding temperature. The single limiting cause, preventing us from attaining burnup of more than 15 % h.à. for the fuel pin design in question, is an enhanced swelling of austenitic cladding material under damaging doses of more than 80 dpà.

In-pile tests and material science investigations of base design fuel pins, which contain metal uranium powder in fuel composition as a getter and have the cladding made of advanced ferrite-martensite steels, confirmed their high serviceability up to the burnup of ~30 % h.à. (Table 3.2). Indi

Table 3.2

Tests of SA, containing mixed vibropack oxide fuel in BOR-60 reactor

Parameter	Value
1. Fuel composition	UO_2+PuO_2, UO_2+PuO_2+U, (UPu)O_2+U
2. PuO_2 mass ratio, %	20-28
3. getter mass ratio, %	3-10
4. Fuel pin cladding diameter×thickness, mm	6,0×0,3; 6,9×0,4
5. Maximum linear power generation, W/ñm	510
6. Maximum cladding temperature	722
7. Maximum fuel burnup, % h.à. • regular SA • experimental SA • experimental fuel pins	 18.0 30,0 32,3
8. SA quantity, pieces total which attained the burnup of: • 10...15 % h.a. • 15...20 % h.a. • > 20 % h.a.	 442 279 11 10

vidual experimental fuel pins attained the burnup of more than >32%h.à. In PIE progress there was no sign either of thermomechanical or physicochemical fuel-cladding interaction in any of the fuel pin cross-sections under analysis. The typical microstructure of vibropack (UPu)O_2+U fuel upon testing in BOR-60 up to the burnup of 30 % h.à is given in Fig.3.2.

Analysis of radiation characteristic of vibropack oxide fuel pin serviceability has shown that:

- using fuel composition, containing (UPu)O_2 + U getter, makes it possible to exclude corrosion processes due to cesium and halogens availability as well as possible technologic impurities, and therefore to remove restrictions in burnup because of physicochemical interactions;
- availability of the initial structure circumferential layer results in the fact, that under transient modes cladding stresses are many times as low, and stress relaxation comes much earlier, than those of pellet fuel pins. As a result, fuel pin changes in SA Core under power ramp (Table 3.3) don't effect fuel pin serviceability; elevated smear density of fuel column (>9,0 g/cm^3) allows us to possess sufficient temperature reserve up to the melting temperature;
- integral value of swelling for vibropack (UPu)O_2+U fuel is (0,6±0,1) %/ % of burnup;
- there is no revealed an influence of granulated fuel (UPu)O_2 or UO_2+PuO_2 production technology upon fuel pin serviceability.

3.2 Tests of mixed vibropack fuel pins in BN-350 reactor

In the period from 1985 till 1986 in BN-350 reactor there were irradiated two experimental SA, containing mixed vibropack oxide fuel (MVOF) and 7 SA with uranium vibropack oxide fuel (UVOF). Their design features and test conditions are given in Table 3.4. According to the data of reactor CIC (Checking integrity of cladding), in operating one of SA, containing MVOF (S-585), were considered to have been failed and even have contacted with coolant. Upon exhibiting failure signs on the 45 operation day (burnup of 1,2 % h.à.), SA was irradiated for 110 more effective days. When cutting SA there was found one failed fuel pin. The other fuel pins didn't have external failures. Cladding leakage of the failed fuel pin took place along the Core center as a cross crack. Fuel was available at the region of the cladding failure. There were no signs of defect propagation, fuel washing out and fuel-coolant interaction. The fuel pins with axial fuel mass transfer were found by gamma-scanning and masstransfer correlation with the fuel column initial smear density was fixed. Investigations determined, that, cause of axial fuel mass transfer and, therefore, occurrence of cladding through defect in the same fuel pin, consists in exceeding actual test parameters over the design ones in combination with the minimum fuel smear density (~8,4 g/ñm^3) in some fuel pins. Fuel pins with smear density of more than >8.6 g/ñm^3

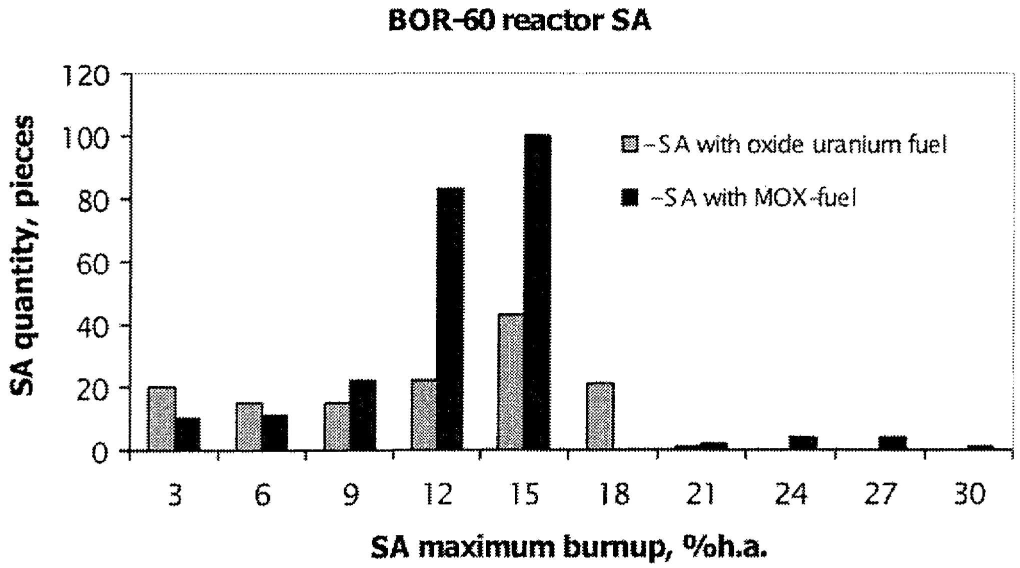

Fig.3.1 SA histogram of BOR-60 reactor

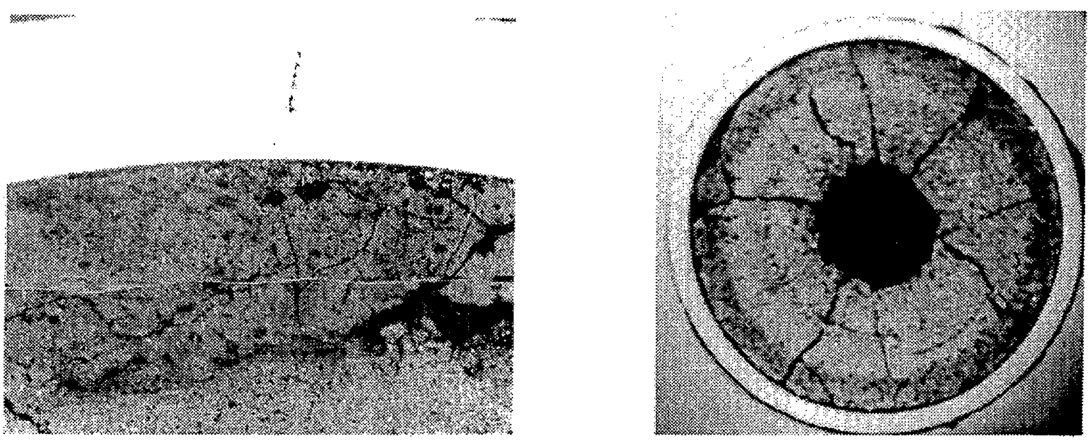

Fig.3.2.Micro- and macrostructure of fuel pin cross section
with burnup 32 % h.à.for BOR-60 reactor

Table 3.3

Test parameters for those BOR-60 SA, which are rearranged in operating

Rearrangement type	Pellet fuel			Vibropack fuel		
	SA quantity, pieces	Burnup h.a.	Failed SA quantity	SA quantity, pieces	Burnup, h.à.	Failed SA quantity
Within the same row	4	10÷12	2	16	8÷24	2*(in 2 Core runs after rearrangement)
From the center toward the circumference	18	10÷12	-	57	7÷22	-
From the circumference toward to the center	4	12÷17	3	85	8÷25	1*(in 5 Core runs after rearrangement)

remained serviceable even at the elevated operational parameters, there were no revealed any anomalies of either fuel or cladding. SA S-586, which attained the burnup by 36 % more than the design one, was unfailed according to the reactor CIC, but after transport procedures of unloading there was registered gas release. Material science investigations showed, that two fuel pins exhibited non-gastightness. Their unsealing was attributed to the excessive ovalization of the cladding, made of EI-847 steel, as a result of enhanced swelling and embrittlement in combination with high level of the stresses due to mechanical interactions of the swelling fuel pin bundle both with each other and with wrapper tube. Additional to the plan parameters of SA tests in BN-350 in conjunction with the variation of initial fuel column smear density enabled to verify experimentally the estimation of limit operational parameters for mixed vibropack fuel pins. From the results of in-pile tests and material science investigations there were made changes in design and in fabrication technology of mixed vibropack fuel pins with the purpose of increasing reliability and their life-time, namely:

- there has been increased minimum value of fuel column smear density up to 8,6 g/ñm^3 and getter mass ratio up to 10 %;
- there has been used more resistant to irradiation construction materials.

All the design upgrade was implemented in manufacturing six experimental SA for BN-600 reactor.

3.3Tests of mixed vibropack fuel pins in BN-600 reactor

In BN-600 reactor there were tested 6 SA containing vibropack MOX fuel, and 4 SA with uranium-oxide fuel as well. In-pile tests of 6 SA under design parameters were successfully completed. Maximum burnup was 9,8 % h.à.(for individual fuel pins -10,9 %), table 3.4.

There were no revealed failed fuel pins in SA at the CIC facility. The results of complex material science investigations of the subassemblies fuel pins with burnup 6,8 % h.à. made it possible to find out, that:

- general condition of all the SA and fuel pin components was satisfactory;
- maximum changes of the cladding diameter and the operating dimension of the wrapper tube didn't exceed 2%, which provided evidence for unexhaust of SA serviceability resource according to the admissible deformation criterion;
- there were no signs of failed fuel pins, the failure of fuel column uniformity and fuel axial masstransfer.

While investigating by metallography there were no revealed any anomalies, overheat signs and cladding corrosion damage both from fuel and from coolant. The comparison of fuel column

Table 3.4

Tests of vibropack fuel SA **in** BN-350 **and** BN-600 **reactors**

Reactor	BN-350			BN-600			
SA No	P1....P7	S-585	S-586	WG-0187	WG-0287	VPC1 - VPC4	WG03 - WG06
the year of fabrication	1982	1984	1984	1987	1987	1989...1990	1990..1991
Fuel composition	UO_2	$(UPu)O_2$		$(UPu)O_2$		UO_2	$(UPu)O_2$
Getter contents (U met.), %	5	5		10		10	10
Plutonium contents, %	-	20		22....28		-	~ 30
Enrichment in U^{235}, %	27	10		-		-	-
Smear density, g/ñm^3	8,8	8,3...8,8		8,9...9,1		8,8...9,2	8,8...9,2
Material of fuel pin cladding	EI-847			EP-172		CHS-68	
Material of SA wrapper	Cr16Ni11Mo3Ti			05Cr12Ni2Mo		05Cr12Ni2Mo	
Thermal loading, êW/m	48	51	48	45	45	42	42...44
Cladding temperature, °Ñ	710	740	690	670	670	680	680
Damaging dose, dpa	45	30	42	53	77	27	76...77
Burnup, % h.à.	7,2	4,7	6,8	6,8	9,6	3,6	9,6 (10,9)
Availability of failed fuel pins: in gas	1*	0	2*	0	0	0	0
in fuel	0	1	0	0	0	1+1	0

* - in carrying out transport operations

structural alteration from metallographic analysis results with those of thermophysical calculation showed a good agreement, which allowed verifying the fuel pin calculation program .

Thus, positive test results both of 6 experimental SA (2 SA - manufacture in the glove boxes, 4 SA- a remote, automated manufacture), containing vibropack MOX fuel, in BN-600 reactor and of fuel pin material science investigations confirmed the efficiency of the technologic decisions and the concepts, which were taken as principles in the mixed vibropack oxide fuel pin design, but in order to substantiate the results and to compile the set of statistical data the tests should be prolonged with the aim of accumulating irradiated SA massif not less than 30 SA in number.

3.4 *Emergency overheat of irradiatedfuelpins*

To study the serviceability of fuel pins under transient cladding overheat conditions in accordance with the operational regulation of BN-600 reactor there was carried out a series of experiments, including an isothermal heat of irradiated fuel under out-pile conditions, as well as the experiment on heat of the cladding up to its melting in the capsule-loop.

Main parameters of irradiated in BOR-60 fuel pins, having different fuel compositions, modes and results of emergency tests are presented in table.3.5.

From the tests and investigations made there were found out the features and regularities of irradiated fuel pin behavior under the emergency overheat. It is shown in particular, that mixed oxide fuel (UO_2-PuO_2-U-getter) pin, irradiated up to the planned and additive to planned burnups, remain sealed under rather severe modes of emergency overheat (for example, temperature of 800-850 °Ñ for 1-

1,5 hrs). Under these modes there was no revealed any corrosion damage of cladding inner surface, as well as signs of plutonium radial masstransfer, but the radial masstransfer of metal FPs took place.

Table 3.5

Main fuel pin parameters, modes and results of overheats

SA index	Material of		Protective layer	Maximum burnup, %	Overheat mode		results
	fuel column	cladding			temperature, °Ñ	Time, min	Cladding corrosion, mcm
ÎG-73	$(U,Pu)O_2$ vpc	E I - 8 4 7	is absent	7	800	90	
ÎG-73	$(U,Pu)O_2$ vpc	EI-847	is absent	7	850	90	
ÎG-115	$(U,Pu)O_2$vpc	EP-450	is absent	21	850	60	
I-805	U	EI-847	UO_2	2,0	770	90	
I-805	U	EI-847	UO_2	2,0	800	90	270
AZ-14i	U-15Pu	EI -847	W or Cr	6,2 - 6,8	740-830	90	24 - 160
ÀZ-15Ì	U-15Pu	EI -847	W or Cr	6,8	740	90	110
AZ-15i	U-15Pu	EI -847	W or Cr	6,8	800	90	160
ÎP-25	UO_2 -tab.	EP-450	is absent	12,6	740	90	200

4.Main results of vibropack fuel pin tests in thermal reactors

An extensive scope of technologic activities, in-pile tests and material science investigations was performed to study the possibility of applying vibropack oxide fuel in thermal reactors. The investigation results also give evidence for a real possibility of upgrading technocoeconomic figures of an advanced fuel cycle for thermal reactor, based on "dry" irradiated fuel reprocessing and vibropacking technology. The principal directions of the investigations are given in table 4.1. In carrying out work physicomechanical and technologic characteristic of granulated fuel were studied, mockup, experimental and pilot fuel pins of VVER type were tested in MIR and SM-2 reactors and then were investigated with material science aims.

Table 4.1

Characteristic and test conditions of pilot mixed vibrooack fuel pins

Kind of investigation	quantity, pieces	ρ_{eff}, g/ñm^3	$Q_{L,max}$ W/ñm	Duration, eff.davs	burnup, Ì W·dav/t	Reference
Exercising	40	10,6...10				l_{ac}=(0,2...4) m
vibropacking	25	,8				u =(0...30) %
technology	12					Gd =(0... 15) %
forming structure,						
thermophysics	**18**	10,3	65	250		
Thermocycling	**35**	9,8	56	535	43000	4300 cycles
Resource tests:						
MIR						
MIR (water boiling	24	9,8	**55**	550	32000	Tests are
loop)	6	10,2	40		47500	completed
MR	12	10,4	50		35900	
MIR (UPuÎ 2 +U,	6	9,8	48		35000	in the reactor
UPuÎ 2+Gd)						
Failed fuel pins :						Initial defect,
UO_2, $(UPu)O_2$	1	10,3	85	500		unsealing at power, endplug defect

5. Conclusions

By the moment in SSC RF RIAR there has been fulfilled the extensive scope of scientific and research activities to validate vibropack oxide fuel pin application in fast and thermal reactors. In carrying out the work physico-mechanical and technologic characteristic of granulated fuel were studied, in-pile tests and material science of mockup, experimental and pilot fuel pins of BN-type (in BOR-60, BN-350 and BN-600 reactors) and WER type (in SM-2 and MIR reactors) were implemented. Mass tests of vibropack MOX fuel pins in BOR-60 reactor in combination with their successful tests in BN-600 reactor, reliable operation of Semi-Industrial Complex Facilities enable to come to the conclusion on a real possibility of using vibropack oxide fuel pins to develop safety, profitable uranium-plutonium fuel cycle on the basis of «dry» technologies as well as to recover plutonium both of reactor and weapon grade in nuclear reactors.