PROGRESS OF THE RUSSIAN RERTR PROGRAM: DEVELOPMENT OF NEW-TYPE FUEL ELEMENTS FOR RUSSIAN-BUILT RESEARCH REACTORS

A.V. VATULIN, Y.A. STETSKIY, V.A. MISHUNIN,
V.B. SUPRUN, I.V. DOBRIKOVA

State Scientific Center of Russian Federation,
A.A. Bochvar All-Russia Scientific and Research Institute of Inorganic Materials
123060 Moscow, VNIINM, P.O. Box 369

ABSTRACT

The new design of pin-type fuel elements and fuel assembly on their basis for Russian research reactors has been developed. The number of following activities has been performed: computational and experimental substantiation of fuel element design; development of fabrication process of fuel elements; manufacturing of experimental assembly for lifetime in-pile tests. The relevant fuel assemblies are considered to be perspective for usage as low-enriched fuel for Russian research reactors.

Introduction

During last years, advanced, new-type fuel assembly (FA) for research reactors was being developed in Russia [1, 2, 3]. Selected conception of (FA) was supposed to be used in all types of Russian research reactors. Pin-type fuel elements (FE) have been proposed in this (FA) instead of tubular-type currently used at present time. The main advantage of pin-type FE is their simplicity in production process. Besides, it is very important that the design and fabrication process of pin-type FE make it possible to utilize dispersion meat with high uranium concentration.

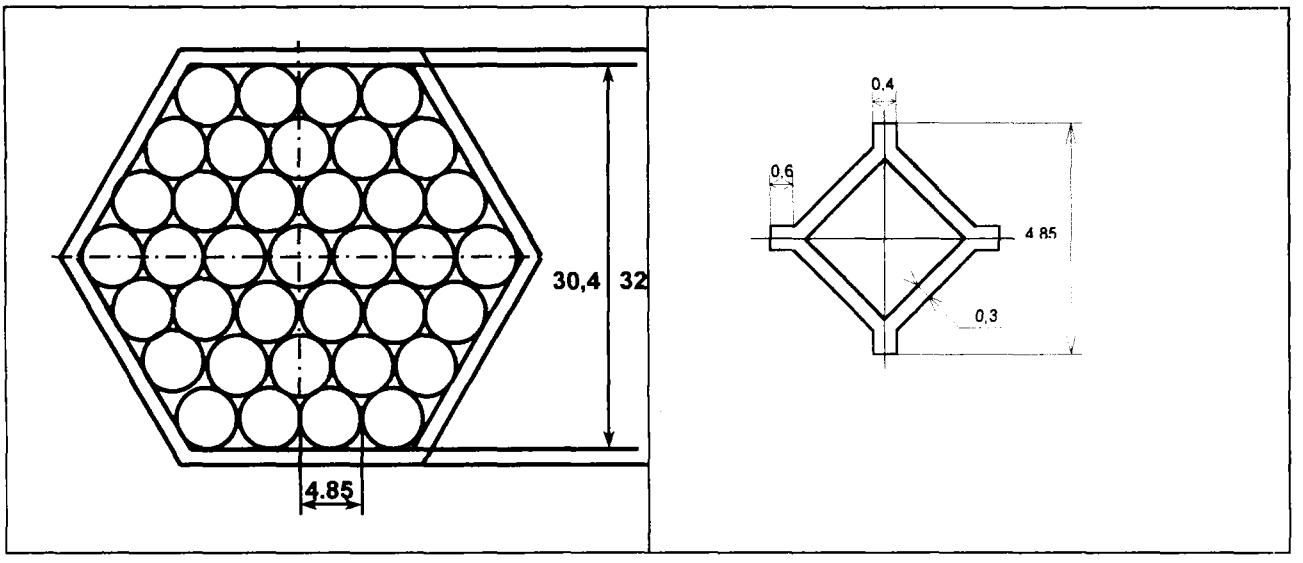
In its turn, this promotes usage of low enriched uranium. The plan of R&D process involved the following activities:

- development of FA and FE design;
- development of FE fabrication process;
- development of plan for irradiation tests;
- manufacturing of experimental FA;
- conducting of irradiation tests.

This paper contains the results of pre-irradiation R&D activities. The works were being performed in the frames of RERTR Program with the support and creative participation of Argonne National Laboratory (ANL, USA).

1. FE and FA design

Fuel element represents the rod (pin) with square cross section and twisted separating fins (spacers) (fig. 1b). The design of experimental FA consists of ending parts, top and bottom separating grids and hexahedral shroud with 37 fuel elements allocated in compact triangular arrangement (fig. 1a). Separating of fuel elements is realized by spiral fins and separating grids disposed in top and bottom parts of shroud. The main dimensional parameters of FE and experimental FA are given in table 1.



a) experimental fuel assemble b) fuel element

Fig.1 Cross section of FA (a) and FE (b).

Table 1. Dimensional parameters

Fuel assembly	
Number of fuel elements in fuel assembly	37
Area of Water Passage (cm^2)	467,3
Heat yield surface (m^2)	0,288
Wettable Perimeter (mm)	682,2
Hydraulic Diameter (mm)	2,74
Volume of fuel (cm^3)	94,8
Volume fraction of Coolant	0,6

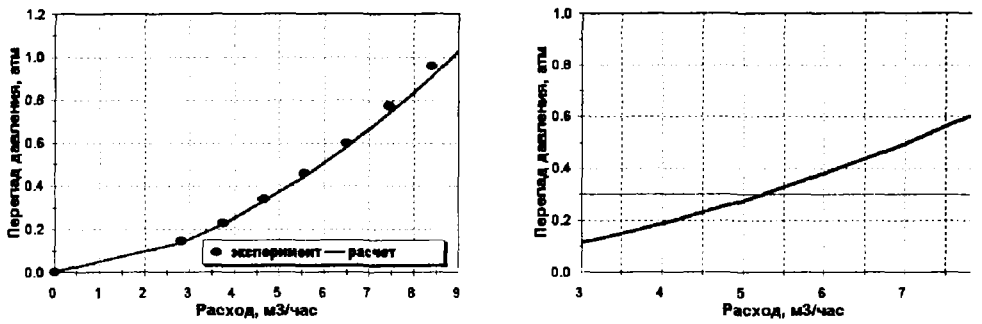
Fuel element	
Pitch of (FE) twisting (mm)	320
Altitude of (FE)/fuel column (mm)	570/500
Circumscribed Diameter (mm)	4,85
Cladding Thickness (mm)	Min 0,3
FE area (mm^2)	9,0
FE perimeter (mm)	15,6
Area of fuel meat (mm^2)	5,12

Computational parameters of FA correspond to that for FA, which are currently operated in VVR-M-type reactor (Hungary, Uzbekistan).

To confirm computational parameters of FA, the hydraulic bench tests have been performed using dummy of fuel assembly (fig. 2).

Fig.2 Dummy of FA for hydraulic tests

Hydraulic parameters of FA have been elaborated on the results of tests. Optimal design of separating grids has been selected taking into account possible vibration of fuel element bundle etc.



a) Dummy FA b) FA of VVR-MS type

Fig.3. Pressure fall vs. consumption

The results of tests showed, that even in the case of usage of only supporting grids, rotation and vibration of fuel elements hadn't been observed even at coolant consumption trough FA more than twice higher than projected one (fig. 3).

2. Fabrication process of FE

Fabrication process of pin-type fuel elements was based on the method of joint extrusion of cylindrical cermet meat and cladding. The main tool for pin-type FE fabrication by this method was forming female die with body size hole of complicated form. Thus fabrication process of pin-type elements has been significantly simplified in comparison with that for tubular FE and has had number of advantages. Very important is that more convenient for extrusion process shape of pin-type fuel element promotes the increase of fuel concentration in the fuel meat up to 50 and higher volume % in comparison with maximum 25-30 vol. % for tubular fuel elements.

Table 2. FE parameters

Parameter	First version	Second version
Fuel component	UO_2	U-9 wt%Mo
U_{235} loading per fuel element (g)	1.27	2.62
Enrichment on U_{235}, %	19,7	19,7
U concentration (g\cm^3)	2.47	5.1

Control of overall FE dimensions, thickness of cladding and dispersion meat has been performed during metallography researchers (fig 5). General view of experimental fuel assembly with pin-type fuel elements is given in figure 6.

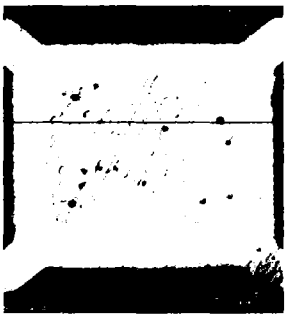


Fig. 5. Cross-section of fuel element

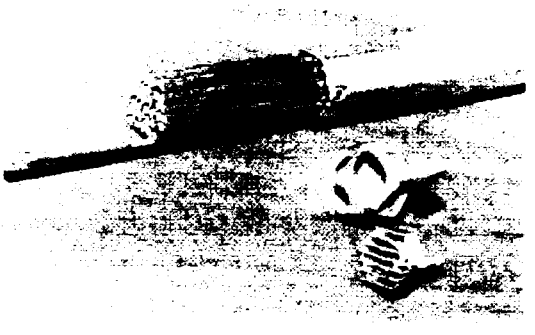


Fig. 6. General view of FA

3. Parameters of in-pile tests

In-pile tests of experimental FA are being planed to be performed in VVR-M5 (Gatchina, RF). Main parameters of in-pile tests are the following:

- average power of FA – 100KW;
- average burn-up an U_{235} – 60%;
- duration of tests - 300 effective days (UO_2)
  - - 600 effective days (U-Mo alloy).

Conclusions

Spadework on arrangements for in-pile tests of experimental fuel assemblies with pin-type fuel elements on the basis of low-enrichment uranium has been carried out.

Developed fuel elements and fuel assemblies can be recommended for usage in Russian research reactors as perspective ones for conversion to LEU.

Acknowledgement

Authors express their gratitude to ANL colleague for aid and creative participation in performing R&D activities.

References

1. A.Vatulin, Y. Stetsky, I. Dobrikova. Unification of Fuel Elements for Research Reactors. 20th Int. Mtg. RERTR 97, Jackson Hole, Wyoming, USA, October, 1997.
2. A.Vatulin, Y. Stetsky, I. Dobrikova. Unified Fuel Elements Development for Research Reactors. 21sh Int. Mtg. RERTR 98, San-Paulo, Brazil, October, 1998.
3. G. Kirsanov, K. Konoplev, Y. Saikov, A. Zakharov. The Test method and some results for WWR-M fuel. 21sh Int. Mtg. RERTR 98, San-Paulo, Brazil, October, 1998.