

RUSSIAN RERTR PROGRAM WORKS STATUS

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ABSTRACT

This paper presents the results of the works under the Russian RERTR Program for the past period and some plans for the future

Introduction

In 1994, a branch program entitled "Design of Fuel Elements and Fuel Assemblies with 20% Uranium-235 Enriched Fuel for Research Reactor Cores" was developed and initiated by the order of the Ministry of the Russian Federation for Atomic Energy.

The major objectives of the Program are as follows:

- Prevention of nuclear weapons proliferation;
- retaining the market for FA supplies to the CIS and East European countries, etc.;
- enabling Russia's participation in competition projects for building research reactors in different countries of the world.

In connection with the lack of financing, the 1994 Branch Program was not implemented in full within the schedule.

Currently, there has been developed and implemented a Russian RERTR program with the completion dates of 2004-2005. It has specified the works with regard for the revision of the concept of certain tasks and their accomplishment dates and also with introduction of new problem solution paths.

Program description

This Program consists of three main phases:

1. **Development and construction of fuel elements and FAs with a $\text{UO}_2\text{-Al}$ based fuel for research reactors built abroad under Russian projects.**
2. **Development and construction of fuel elements and FAs with high-density fuel (HDF).**
3. **Development of new generation fuel elements and FAs for research reactors.**

Status and prospects

Phase 1 consists of two sub-phases.

Sub-phase 1 – development and construction of fuel elements and FAs of the IRT-4M type (see Fig. 1) for reactors in Czech Republic and Uzbekistan.

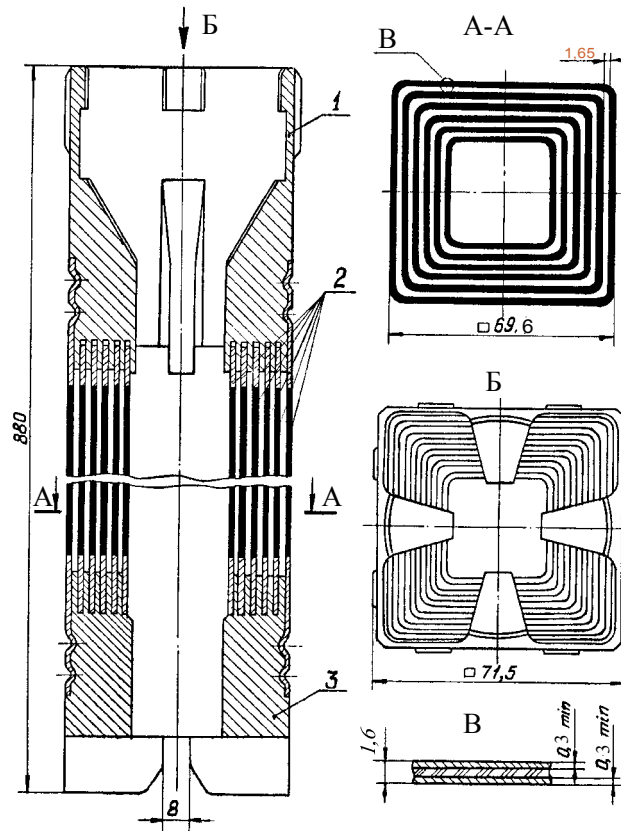


Fig.1. IRT-4M FA
(1-head, 2-fuel elements, 3-tail)

The design drawings and specifications as well as the fabrication forms and records for IRT-4M fuel elements with the uranium concentration 3.85 g/cm^3 in their meats were developed.

The Novosibirsk Chemical Concentrate Plant has manufactured one combined 6-tube IRT-3M FAs with two IRT-4M fuel elements and three 8-tube IRT-4M FAs for in-pile service life tests in the IR-8 reactor at the Russian Research Center "Kurchatov Institute". The fuel elements failure occurred in the IRT-4M FAs just after the tests started.

A conclusion was made based on the result of the analysis, additional studies and process optimization that the above uranium concentration in this fuel element type is close to the limiting value.

A decision was taken and implemented to manufacture four IRT-4M FAs with the uranium concentration of 3 g/cm^3 .

The service life tests of these FAs were conducted in the VVR-SM reactor in Uzbekistan during the period of November 2000 to March 2002.

The average fuel burnup of $\sim 60\%$ was achieved in all four FAs. And the maximum fuel burnup, with regard for the axial and radial power peaking in the FAs, was 92.6% .

Because it was not possible to conduct post-irradiation examinations of these FAs, the Novosibirsk Chemical Concentrate Plant manufactured two combined IVV-2M FAs (see Fig. 2), in which two internal fuel elements have the same uranium concentration of 3 g/cm^3 . These FAs were

tested in the IVV-2M reactor at RDIPE's Sverdlovsk Branch in 2001 without evident failures to the average burnup of 50-60% in the experimental fuel elements. These fuel elements were subjected to post-irradiation material studies, whose results have demonstrated their functionality to the burnup not less than 60%.

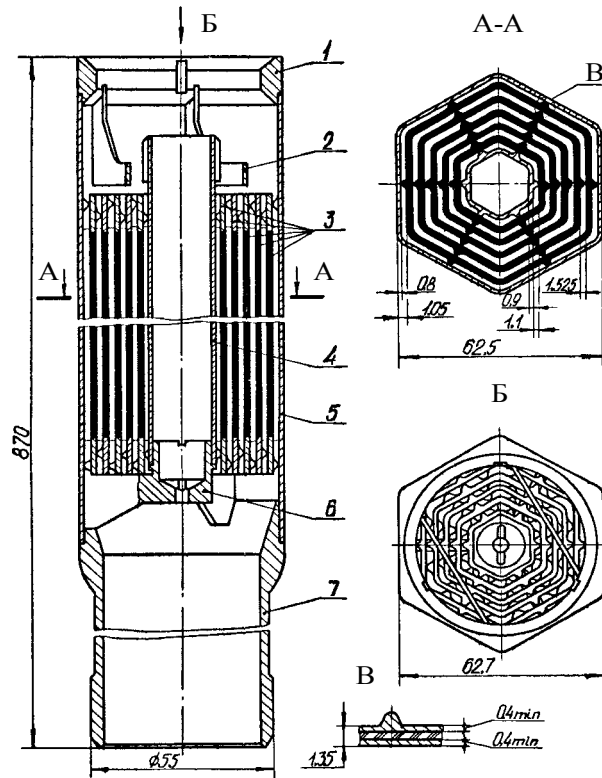


Fig.2. IVV-2M FA

(1–head, 2–restricting plates, 3–fuel elements, 4–internal sheath, 5–external sheath, 6–support bushing; 7–tail)

The Research Institute for Inorganic Materials and RDIPE have developed detailed designs for the IRT-4M fuel elements and FAs.

Work is presently done at the Novosibirsk Chemical Concentrate Plant to prepare these FAs for the plant acceptance tests and their commercialization (licensing) to be finished in 2003.

Sub-phase 2 – development and construction of VVR-M2 fuel elements and FAs (see Fig. 3) for the reactor in Hungary.

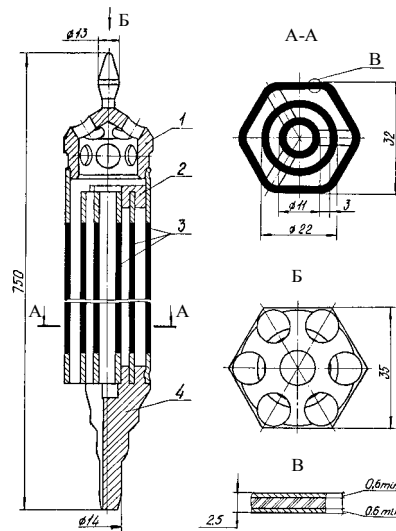


Fig.3. VVR-M2 FA
(1–head, 2–collar, 3–fuel elements, 4–tail)

Five FAs were successfully tested in the VVR-M reactor, St. Petersburg Nuclear Physics Institute, to the burnup values of 75-80%.

The Research Institute for Inorganic Materials and RDIPE have developed detailed designs of the VVR-M2 fuel elements and FAs.

Plant acceptance tests were successfully held at the Novosibirsk Chemical Concentrate Plant in late 2001 and this FA type was commercialized (licensed).

Phase 2

Development and construction of fuel elements and FAs with high-density fuel (HDF)

Competitions for designs of research reactors are periodically announced in different countries. The requirements for these designs are becoming increasingly stricter. As a rule, customers want to have a multi-purpose reactor with the power of 10-30 MW and the uranium-235 fuel enrichment of not more than 20%, and this, accordingly, requires the creation of high uranium fuel compositions being at the world market competitive as well as high heat rated cores.

RDIPE has developed several generic designs of research reactors that can be proposed for such competitions.

Such reactors require the uranium concentration in fuel to be $5-7 \text{ g/cm}^3$.

At present time, the world leading countries in fuel development (USA, France, Japan, FRG) are paying an increasingly keen attention to high uranium fuel compositions based on UMo and U-Zr-Nb, and this information is regularly presented at annual international conferences on the problem of reduced fuel enrichment in research and test reactors (RERTR).

Based on the Russian experience of long-term U-Mo alloy employment as a dispersed fuel composition for the fuel elements of the AM reactor (The First in the World Nuclear Power Plant),

scientific potential and additional studies undertaken at the Institute of Physics and Power Engineering in Obninsk and the Research Institute for Inorganic Materials, the uranium-molybdenum alloy based fuel was selected.

Laboratory facilities for production of powders of a uranium-molybdenum alloy have been developed and manufactured.

The Novosibirsk Chemical Concentrate Plant manufactured two combined IVV-2M FAs, in which two inner fuel elements have the U-9%Mo based fuel with the uranium concentration of 5.4 g/cm^3 , jointly manufactured by the NCCP and the Institute of Physics and Power Engineering.

In-pile service life tests of these FAs were conducted at RDIPE's Sverdlovsk Branch to the planned average burnups of 40% and 60%.

Post-irradiation material studies of these fuel elements should be conducted this year.

Phase 2 involves the development and construction of IRT-3M fuel elements and FAs (see Fig. 4) with high-density uranium-molybdenum alloy based fuel and also their tests in reactors in Czech Republic or Uzbekistan.

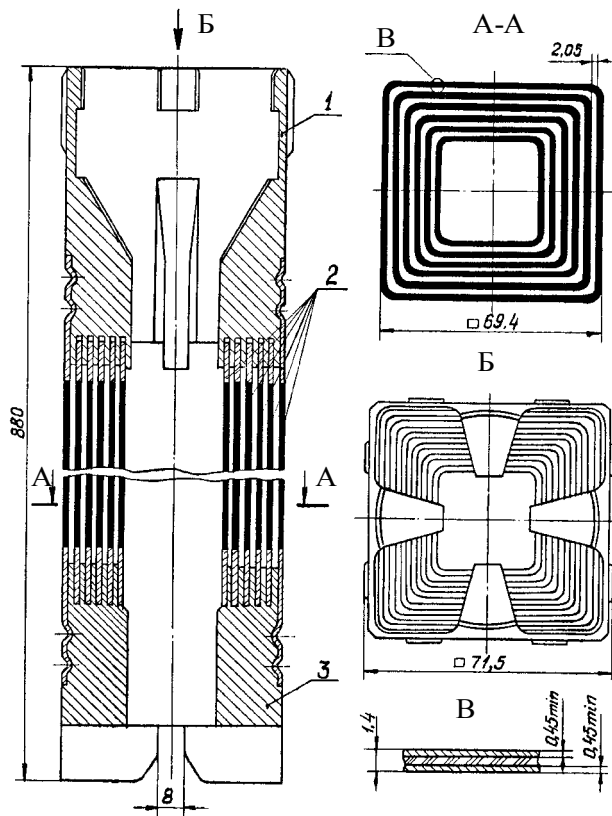


Fig.4. IRT-3M FA
(1–head, 2–fuel elements, 3–tail)

The reason is that this FA type has a high specific heat removal surface and, if using a high-density fuel, a high specific uranium content and good operating performance. All this considerably improves the competitiveness of research reactor cores based on these FAs.

If required, the future use of a high-density fuel in Russian research reactors will enable their transfer to a low enrichment fuel.

Works on the high-density fuel and IRT-3M FAs on its basis, including the development of detailed designs for fuel elements and FAs and their commercialization (licensing), are planned to be completed by 2005.

Phase 3

The purpose of the work at this phase is to design new generation fuel rods for research reactors and, hence, ensure the modern level of research reactors developed under Russian projects and make them competitive at the world market.

The fuel of Russian research reactors was developed in the USSR during the initial period of developments in this field. Several reactor types (VVR-M, MIR, IRT) and respective fuel element and fuel assembly types of different design were designed. Fuel elements of all reactor types meet in essence the required operating parameters and are rather reliable. But the design of fuel elements (thin-wall three-layer tubes of different configurations) limits the potential for raising the fuel component, which complicates the solution of the problem concerning the use of a low enrichment fuel.

It is becoming a tradition now when the customer of a research reactor desires to obtain the entire cycle of fuel element and FA fabrication.

In this situation, it is becoming evident that it is necessary to develop a new generation fuel element for research reactors that would possess the required technical and economic characteristics, high manufacturability and would be unified to be used in as many reactor types as possible with keeping the strengths of the existing Russian fuel elements in place (see Figs. 5 and 6).

The Research Institute for Inorganic Materials has reported on the development of such fuel element more than once.

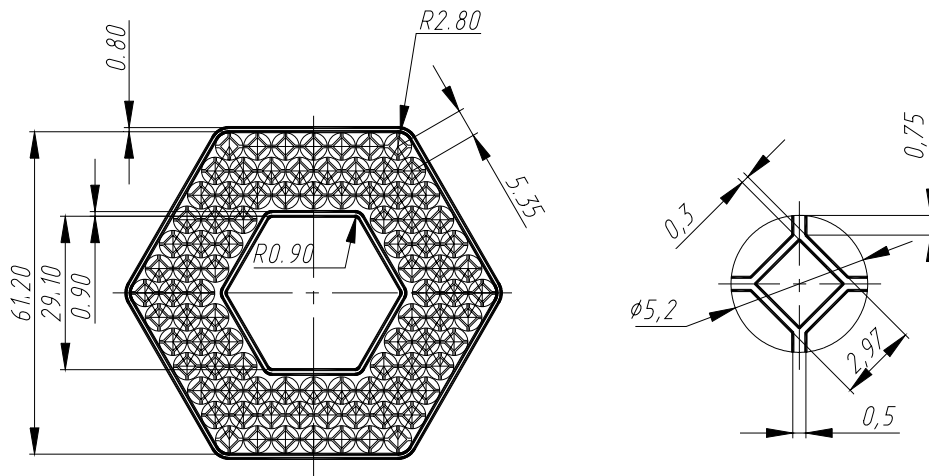


Fig.5. IVV-2MS FA

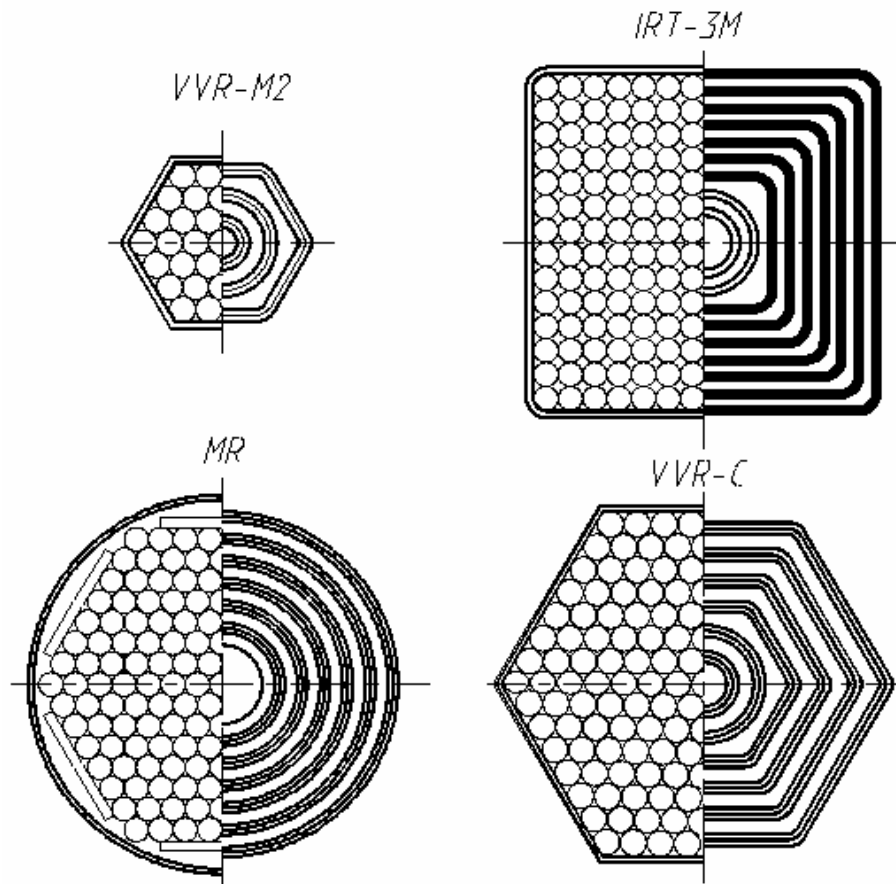


Fig.6. Cross-sections of FAs for research reactors

In this connection, the work is underway at research institutes of the Russian Ministry for Atomic Energy to develop a principally new fuel element and FA design for research reactors. It takes into account the necessity of securing the following most important results:

- providing a high specific heat transfer surface;
- using reduced enrichment uranium (less than 20%);
- maximum unification with regard for all reactor types;
- simplicity and reproducibility of the manufacturing technology;
- higher technical and economic characteristics of manufacturing;
- competitiveness at the world market.

The available scientific and technical results are the basis for the development efforts to design a new generation fuel element for the existing projects of Russian research reactors.

The activities at this phase include feasibility studies of the fuel element and FA serial manufacturing technology, development of design and process documentation, manufacturing technology, manufacturing of experimental FAs with fuel rods and in-pile tests and post-irradiation examinations, development of detailed designs for fuel elements and FAs and their commercialization.

It is planned to finish the work in the R&D scope by the end of 2005.

CONCLUSION

Therefore, Russia will be ready to supply IRT-4M FAs with a low enrichment fuel for research reactors in Czech Republic, Uzbekistan and Libya by the end of 2003 and is ready to supply VVR-M2 FAs to Hungary already now.

Works will be continued on high-density fuel. Post-irradiation material examinations of the experimental IVV-2M fuel elements have been conducted. In-pile tests of several IRT-3M FAs with a uranium-molybdenum fuel are planned in a reactor in Czech Republic or Uzbekistan. The question of which of the reactors will be used in particular is being solved now.

Next year, it is planned to test fuel rods with different fuel types simultaneously in several reactors: in the VVR-M reactor in Gatchina, in the MIR reactor in Dimitrovgrad and in the IVV-2M reactor in Zarechny.