THE RUSSIAN RERTR PROGRAM WORKS STATUS

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Abstract

This paper presents results of the work under the Russian RERTR program for the past period and some plans for the future.

Currently the work under the Russian RERTR program is carried out in two fields:

The first field is the development of fuel elements and FAs of the VVR-M2, MR and IRT-4M type with the fuel enrichment of 19.7% based on the UO2-Al composition that has been already used in these FAs but with a higher uranium concentration of 2.5-3 g/cm3;

The second field is the development of a high-density fuel composition (HDF), and the development of fuel elements and FAs on its basis with the uranium concentration of >6 g/cm3.

The following work was done and is being underway in **the first field:**

Optimization neutronic and thermohydraulic analyses have been performed in RDIPE for the conversion of the research reactors in Czechia, Hungary and Poland to a low-enriched (19.7% in uranium-235) fuel of UO2-Al.
To substantiate the serviceability of FAs of the IRT-4M type with the uranium-235 loading of 300 g, 4 FAs have been manufactured at the Novosibirsk Plant and their testing will be started soon up to different burnup levels of 40-60% in a research reactor in Uzbekistan.

Due to the impossibility of a post-irradiation examination of these FAs being carried out at that reactor, there have been developed and will be manufactured 2 combined FAs of the IVV-2M type with two fuel elements having the same characteristics as the tested IRT-4M fuel elements. To ensure the required heat flux in 2 fuel elements of the combined IVV-2M type FA, the enrichment of 36% in uranium-235 has been assumed. These combined FAs will be subject to a post-irradiation research after performance
in-pile tests in the IVV-2M reactor at RDIPE's Sverdlovsk Branch.
Work is carried out to put out the detailed design of the VVR-2M FAs by the end of this year.
The in-pile life tests are currently continued:
- 5 VVR-2M type FAs are being tested in the VVR-M reactor at St.Petersburg Institute of Nuclear Physics.
- a combined IRT-3M type FA is being tested in the IR-8 reactor at the Kurchatov Institute. The burnup of ~33% has been so far reached.
- 3 MR type FAs were tested in the MIR reactor at the Institute of Nuclear Reactors in Dimitrovgrad. Two FAs have the average enrichment of ~30% at the time. The 3rd FA has been unloaded with the burnup of ~8% due to depressurization. A post-irradiation research of the combined MR type FA that was previously removed from the reactor on a suspicion of being non-leaktight, is planned for this year.

Besides the above work in the first field, the following work was done at:

At the Novosibirsk Plant:

There was developed the technology of manufacturing fuel elements and FAs of the IRT-4M type with the uranium-235 loading of 300 g and with two types of cladding materials (SAV-1, AMg2). The fuel elements with the cladding of AMg2 have the best results. There has been determined the optimal size of fuel particles of 100-600 micro-m.

There has been analyzed 3 prematurely unloaded FAs of the IRT-4M type during tests in the IR-8 reactor. Reasons: implantation of large particles into the cladding up to its rupture at their introduction points.

There was developed the model of the technology for production of fuel elements with the maximum bulk density of the fuel.

At the Kurchatov Institute:

There has been conducted a metallographic research of 2 IRT-4M type FAs that failed during radiation tests. Extensive swellings have been found in certain fuel
elements.

The following work was done and is underway in **the second field:**

At the Physical Energy Institute, Obninsk:

The uranium alloys U- Mo (9 wt %), U- Zr (10 wt %), U- Zr (5 wt %) - Nb (5 wt %), U- Nb (5 wt %), have been considered for use in the dispersed fuel composition of IR fuel elements with the U-235 enrichment of no more than 20% of the uranium alloys ensuring the uranium concentration in the fuel at a level of about 6-7 g/cm3,

The optimal uranium alloy was chosen based on the results of a comparative research for:

- the compatibility of the components of dispersed fuel compositions at working temperatures and at temperatures of process operations in the course of manufacturing.
- the corrosion resistance of fuel compositions in the coolant environment.

The research for the compatibility of the components has not revealed advantages of any of the considered uranium alloys. All considered alloys have shown a satisfactory compatibility with the matrix and cladding materials both at working temperatures and at process temperatures for the fuel element manufacturing.

The corrosion resistance tests have shown an obvious advantage of the U-Mo (9 wt %) alloy over other uranium alloys.

Based on the conducted research, the U- Mo (9 wt %) alloy was chosen as a fuel ingredient of the dispersed composition for the research reactors.

The experience of long-term operation of the U- Mo (9 wt %) alloy as a fuel ingredient of the dispersed fuel composition for the fuel elements of the AM reactor (the world's first nuclear power plant), has shown its high radiation stability at irradiation temperatures of up to T=400 °C.

The technology development for manufacturing the dispersed fuel composition A1 (enrichment 60% by vol.)+U- Mo (9 wt %) (enrichment 40% by vol.) has shown that hot pressing (T=450-500 °C) allows to obtain the density of 96.6% of the theoretical value.

The heat conduction of hot-pressed specimens at T=50-300 °C was 49-55 W/(m °C) for the dispersed composition with irregularly shaped uranium alloy particles and 82-83 W/(m °C) for the dispersed composition with the spherically shaped uranium alloy particles.

There has been developed a conceptual waste processing technology scheme for the fuel element production including:

- dissolution process;
- grit separation from the solution;
- grit washing - «clarification» process;
- fuel grit drying;
- grit quality control;
- quality control of grit returned to production.

To produce the grit (powder) of a metal fuel, the method of dispersion of the rotating electrode has been chosen. There has been developed the fuel grit production technology. There has been developed and manufactured a laboratory plant allowing to produce a fuel metal grit with specified dimensions of spherical particles by dispersion of the melt under centrifugal forces in an inert atmosphere.

At RDIPE:

There have been developed Requests for Proposal for the combined FA of the IVV-2M type with 2 fuel elements having the U-Mo (9 wt %) fuel. To ensure the required power release in 2 fuel elements of the combined FA of the IVV-2M type, the enrichment of 36% in uranium-235 has been assumed. The grit of the U-Mo (9 wt %) fuel will be produced at the Physical Energy Institute and delivered to the Novosibirsk Plant for the manufacturing of the IVV-2M type fuel elements. Currently, a program is being developed and safety is being substantiated for radiation tests of these FAs in the IVV-2M reactor to be manufactured at the Novosibirsk Plant this year.

At the Bochvar' Institute for Inorganic Materials:

The work was being performed in the following fields:

An uranium mononitride (UN) based fuel:
- a granule preparation technology has been developed;
- a fuel element manufacturing technology has been developed;
- there has been substantiated a waste reprocessing technology which may be used by process scheme used for uranium dioxide without changes;
- a pre-irradiation research of the fuel and the fuel elements has been conducted.

A high-density uranium alloys based fuel:
- there have been developed and studied high-density uranium alloys of the systems:
U-Mo, U-Zr-Nb, etc.
- there has been developed the technology of manufacturing granules, including by dispersion method;
- there has been done a pre-irradiation research of the fuel compositions U-Mo+Al, U-Zr-Nb+Al, etc.

All-purpose rod-type fuel elements and FAs based on them:
- there has been done a thermal analysis of the FAs, and optimal geometrical dimensions and configuration of the fuel elements have been determined;
- an FA mockup design has been developed;
- bench hydraulic tests of the FA mockups have been conducted;
- a process scheme for fuel element manufacturing has been developed.

A theoretical research of the radiation behavior of uranium alloys:
- a mathematical (computer) model of the radiation behavior of uranium alloys was being developed;
- preliminary computer codes of the radiation swelling of high-density uranium alloys have been developed;
- models were being verified based on the results of the in-pile tests.

References

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