Available online at www.scholarsresearchlibrary.com

Extended Abstract

Archives of Physics Research, 2021, 13 (1)
(https://www.scholarsresearchlibrary.com/journals/archives-of-physics-research/)

ISSN 0976-0970
CODEN (USA): APRRC7

Fast reactor with liquid U-Pu fuel: Its applications and fuel cycle

Leonid Ponomarev

A A Bochvar High-Technology Scientific Research Institute for Inorganic Materials, Russia
E-mail: leonidp2008@mail.ru

Fast reactor is the necessary element of the future nuclear power. But the contemporary fast reactors are not inherently safe (in Weinberg's definition) and have the serious problems with the fuel nuclear cycle closing, the low fuel element burning and their repeated fabrication from the hot spent fuel. Molten salt reactors (MSR) are free from these shortages. Their void and temperature coefficients are negative; they do not need in the fuel elements fabrication and give the opportunity to organize online hot spent fuel reprocessing. First MSR was in operation during almost 5 years with Th-U fuel and thermal neutron spectrum, which is adequate for this fuel (MSRE, Oak Ridge, 1964-1969). However its neutron balance is poor in comparison with U-Pu fuel and fast neutron spectrum. This is impossible to combine all three ideas (fast spectrum, molten salt and U-Pu fuel) yet because the PuF3 solubility in the fluoride salts is too less. Five years ago it was established experimentally that PuF3, UF4 and AmF3 solubility in the eutectic 46.5 mol% LiF-11.5 mol% NaF-42.0 mol% KF (FLiNaK) are equal to 33, 45 and 43 mol% respectively at 700°C. This observation opens the way for the development of the fast molten salt reactor with U-Pu fuel cycle (U-Pu FMSR) as well as the effective FMSR reactor-burner of Am. U-Pu FMSR based on FLiNaK can work in the equilibrium mode at the concentration UF4 and PuF3 22 and 7 mole% respectively using as a fuel 238U only. FMSR reactor-burner can transmute ~300 kg Am/year·MWth without Pu feeding, i.e., one GWth FMSR-burner can disintegrate Am from the spent fuel of ~40 standard 1 GWe thermal reactors after 5 years of cooling.
It is generally recognized that long term development of nuclear power as part of the world's future energy mix will require fast reactor technology with a closed fuel cycle. Fast reactors in the closed fuel cycle represent both the cornerstone of and a bridge to more sustainable nuclear energy production. In the past few decades, fast reactors have been brought to a high level of maturity by the design, construction and operation of experimental and prototype reactors. A number of countries are actively developing fast reactors and there are several demonstration projects, of a variety of sizes, under study or under construction. Progress has been made as well in the development of related fuel cycles with processes being demonstrated at pilot plant scale. The IAEA has been supporting the development and deployment of fast reactor technology and serving interested Member States for almost five decades. The Technical Working Group on Fast Reactors (TWG-FR) and the Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management (TWG-NFCO) comprise groups of experts providing advice and support for the implementation of IAEA programmatic activities, reflecting a global network of excellence and expertise in the areas of advanced technologies and R&D. Among the wide range of activities and initiatives carried out under the aegis of these two working groups, the International Conference on Fast Reactors and Related Fuel Cycles is a major event.
The first International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunities (FR09) was held in Kyoto, hosted by the Government of Japan. The event provided an appropriate forum to achieve the main objectives of sharing knowledge and exchanging information, experience and innovative ideas among the more than 500 experts from 20 countries and 3 international organizations in attendance. The IAEA organized the second conference, on the theme of Safe Technologies and Sustainable Scenarios (FR13), in Paris, in 2013, hosted by the Government of France. This second event was attended by almost 600 experts from 27 countries and 4 international organizations representing different fields of fast reactor and related fuel cycle technologies. Continuing this effort, in 2017 the IAEA organized the third international conference, on the theme of Next Generation Nuclear Systems for Sustainable Development (FR17). Held in Yekaterinburg and hosted by the Government of the Russian Federation, the FR17 conference was attended by some550 participants from 27 countries and 6 international organizations. The purpose of the FR17 conference was to provide a forum to exchange information on national and international programmes, and more generally on new developments and experience, in the field of fast reactors and related fuel cycle technologies. By providing a scientific platform for experienced scientists, engineers, government officials, safety officers and fast reactor managers to share their perspectives, the FR17 conference also facilitated the exchange of knowledge between generations. Such exchange can help in choosing the correct path of research to meet the upcoming challenges in the development of fast reactors and related fuel cycles.

At present, many countries are actively developing reactor, coolant, fuel and fuel cycle technologies. Fast reactor technologies under development include sodium, lead, gas, molten salt and supercritical water cooled systems, as well as hybrids, such as accelerator driven systems. Several demonstration projects, ranging from small to large scale, are under study, design and construction. For energy systems based on fast reactor to become viable for industrial deployment in the coming decades, designers will have to increase their level of safety in order to gain public acceptance. Harmonization of safety standards at an international level will play a leading role in achieving these goals.

Bottom Note: *This work is partly presented at 5th World Congress on Physics July 17-18, 2018, Prague, Czech Republic*