MANAGEMENT OF RADIOACTIVE WASTE IN NUCLEAR POWER: HANDLING OF IRRADIATED GRAPHITE FROM WATER-COOLED GRAPHITE REACTORS

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One of the topical issues of nuclear power today is decommissioning of power, production and research nuclear reactors with expired lifetime. In addition to technical, economic and social matters, decommissioning involves ecologically safe confininement of radioactive waste (radwaste) that is generated, in particular, during dismantling of highly radioactive reactor components.

As a result of decommissioning of water-cooled graphite-moderated reactors, a large amount of radwaste in the form of graphite stack fragments is generated (on average 1500-2000 tons per reactor). That is why it is essentially important, although complex from the technical point of view, to develop advanced technologies based on up-to-date remotely-controlled systems for unmanned dismantling of the graphite stack containing highly-active long-lived radionuclides and for conditioning of irradiated graphite (IG) for the purposes of transportation and subsequent long term and ecologically safe storage either on NPP sites or in special-purpose geological repositories.

The main characteristics critical for radiation and nuclear hazards of the graphite stack are as follows:

- the graphite stack is contaminated with nuclear fuel that has gotten there as a result of the accidents;
- the graphite mass is 992 tons, total activity - 6?104 Ci (at the time of unit shutdown);
- the fuel mass in the reactor stack amounts to 100-140 kg, as estimated by IPPE and RDIPE, respectively;
- γ-radiation dose rate in the stack cells varies from 4 to 4300 R/h, with the prevailing values being in the range from 50 to 100 R/h.

Traditional methods of radwaste handling

In general, radwaste conditioning means waste processing to achieve pre-determined properties, parameters, characteristics or a new state. Typical requirements to radwaste conditioning include reduction in volume, dehumidification (dry material), formation of solid radwaste (SRW) from liquid radwaste, fractionation, i.e. separation of highly-active waste from lower activity waste, etc.

Bituminization technology for radwaste processing is used in many countries with highly developed nuclear power. This technology is especially useful in such countries where dry territories suitable for radwaste storage (e.g., deserts, dry sands, etc.) are unavailable. This technology uses bitumen blocks that can be stored in the ground and in other places not protected from underground water.

Cementing technology for processing lower activity radwaste is popular in the countries where dry solids and beds free from underground water are available.

In recent years, the investigations conducted in some countries were focused on exploration of synthetic resins and polymers as possible binders for graphite radwaste.

Incineration of IG has an important advantage over any other methods of graphite handling after dismantling, because the amount of radwaste intended for disposal will be significantly reduced as a result of incineration.

As commonly accepted in Russia and abroad, the graphite stacks of gas- and water-cooled graphite-moderated reactors planned for decommissioning shall be preliminarily cooled during the 50 to 100 years in the reactor cavity, where it is isolated from the environment. Priority of this concept relegates to the background the efforts on development of cost-efficient technologies for safe handling of IG. As a result, technology of IG handling mastered in the industrial scale is not available in Russia today.

In terms of IG handling technology two lines were identified: long-term storage of conditioned IG and IG disposal by means of incineration.

The specific cost of graphite immobilization in a radiation-resistant polymeric matrix amounts to ~2600 USD per 1 t of graphite, whereas the specific cost of immobilization in slag-stone containers with an inorganic binder (cement) is ~ 1400 USD per 1 t of graphite. On the other hand, volume of conditioned IG radwaste subject for disposal, if obtained by means of the first technology, is 2-2.5 times less than the volume of radwaste generated by means of the second technology. Besides, the duration of radwaste processing, including IG conditioning, package set transportation, and disposal is much shorter, if performed in accordance with the first technology. Thus, the final choice of graphite immobilization technology shall be made in the course of a feasibility study on decommissioning of water-cooled graphite-moderated reactors, accounting for the strategy of futher graphite radwaste handling in the region of NPP locations.

It can be concluded from the above that advanced methods for graphite radwaste handling are available today. Implementation of these methods will allow enhancement of environmental safety of nuclear power that will benefit its progress in the future.