Accelerator Based Conversion of Surplus Plutonium

Reductions in the number of nuclear weapons in the United States and the former Soviet Union have resulted in tons of weapons-grade plutonium that need to be disposed of safely. Storage facilities are needed for the near term, but the ultimate disposition is also important. Some solutions involve converting the plutonium to a form similar to other high-level wastes destined for geologic repositories, such as spent reactor fuel and glassified wastes. Those forms would be substantially more proliferation-resistant than the present concentrated form. Even so, plutonium originating from weapons programs and the larger, growing quantities of plutonium from commercial spent fuel would continue to present a proliferation nuisance.

The Accelerator Based Conversion (ABC) technology under investigation at the Laboratory and illustrated in the figure could be used to destroy plutonium from both weapons and commercial reactors. The technology is being designed to transmute the “dominant” long-lived radioactive products generated during plutonium consumption (those that are most difficult to dispose of safely) and to generate electric power from the heat released by the various conversion processes. Initially, ABC systems could destroy the plutonium returned from the weapons program. They could also reduce the long-term toxicity of existing defense wastes destined for a geologic repository. In the longer term ABC plants could consume plutonium, other actinides, and dominant long-lived radioactive waste present in spent fuel from nuclear reactors. Accelerator-based conversion systems would transmute these long-lived radioactive materials into stable or short-lived fission products. The controlled consumption of plutonium afforded by ABC technology could thus provide an international method to reduce opportunities for proliferation.

As shown in the figure, the ABC system uses a proton beam from the accelerator to produce an intense neutron source at the target. The blanket surrounding the target contains plutonium and other actinides that are to be destroyed. The neutrons from the target are moderated, or slowed down, in the blanket, where they induce fission of the unwanted materials, which, in turn, releases more neutrons. Some of these neutrons are captured in the nuclei of long-lived fission products and thereby transmute those nuclei to short-lived or stable products. The intense flux of thermal neutrons allows the ABC system to have lower inventories of actinides and fission products for a given burn rate of those materials than other proposed systems for burning plutonium and long-lived wastes. Further advantages include smaller end-of-life inventories and potential safety enhancements. The fast burn-up of material in the ABC method requires frequent chemical processing to remove the stable and short-lived products for disposal. The unfissioned actinides, including plutonium, and dominant long-lived fission products are returned to the blanket for further exposure to the high neutron flux. The addition of accelerator-produced neutrons to the blanket not only ensures that adequate numbers of neutrons are available to transmute all of the unwanted materials but also provides for subcritical operation in the blanket and therefore prompt control of fission reactivity. This type of control may prove to be particularly advantageous in designs involving very high neutron fluxes and continuous flow of material through the blanket. The heat generated by fission in the blanket is converted to electric power. Some of this electric power can be used to run the accelerator, and the rest can be made available to the electric-power grid. □