All indications of test results have been that cesium is not volatized during the chlorination of zirconium and volatilization of $ZrCl_4$. The degree of decontamination of the product salt appears to depend on effective filtration of the gaseous $ZrCl_4$ to capture entrained particulates contaminated with nuclides, such as Cs-137.

Process development tests have shown that average chlorination reaction rates of about 30 percent per hour, based on the initial reactor clad loading, can be achieved if adequate cooling capacity can be designed into the chlorination reactor and if the zirconium oxide layer is effectively removed. Tests performed with glassware and 500 g of cladding per batch did not have adequate cooling; however, average reaction rates were still acceptable (about 10 percent per hour).

Tests with nonradioactive Zircaloy have indicated that the tin, iron, and niobium alloying components found in fuel cladding can form volatile species that accompany the $ZrCl_4$ product. The radioactive Nb-94 activation product in UNF cladding may be a concern in higher-burnup UNF cladding; also antimony-125 in shorter-cooled UNF cladding may be a concern. Therefore, the current flow sheet (Fig. 2) indicates the need for a purification step for the product $ZrCl_4$ salt, and process development tests have begun to determine effective means for purification. Two university teams have been funded by the U.S. Department of Energy's Nuclear Energy University Program to study alternative methods of $ZrCl_4$ salt purification in collaboration with the current lead effort at ORNL.

Conclusions

Significant progress has been accomplished on developing a chlorination process for removing the zirconium in UNF cladding and purifying the product salt for reuse, possibly in the manufacture of new cladding, or at a minimum to meet specifications for disposal as low-level radioactive waste. Either end point will allow a significant economic advantage, since costly disposal by means of emplacement in a geologic repository will not be required. Currently, the UNF cladding from industrial-scale reprocessing of UNF represents essentially the same volume of waste requiring geologic emplacement as that from the high-level radioactive waste fission products, so a volume reduction of 50 percent is possible.

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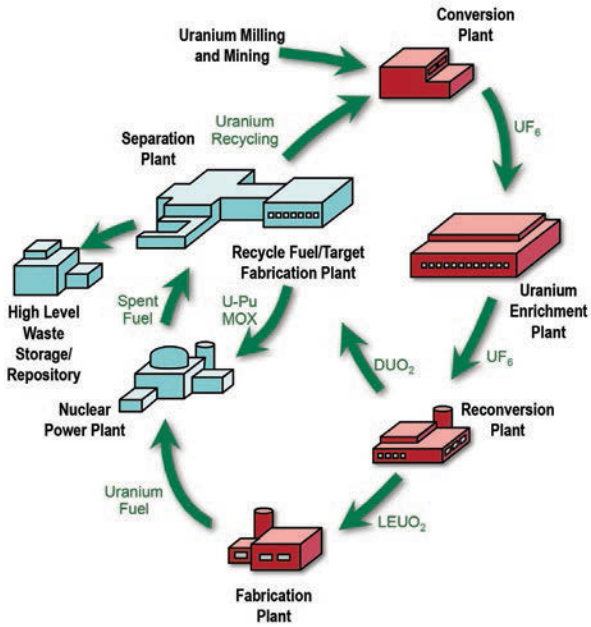
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