RECYCLING ISSUES FACING TARGET AND RTL MATERIALS OF INERTIAL FUSION DESIGNS

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Designers of heavy ion (HI) and Z-pinch inertial fusion power plants have explored the potential of recycling the target and recyclable transmission line (RTL) materials as an alternate option to disposal in a geological repository. The choice between disposal and recycling primarily depends on the volume of the target/RTL waste relative to the nuclear island waste and the economics of the recycling process. Although the physics basis of the HI and Z-pinch concepts is widely different, many of the recycling issues facing both designs are quite similar. This work represents the first time a comprehensive recycling assessment was performed on both machines with an exact pulse history. The irradiation schedule begins with inserting the target/RTL into the nearly spherical chamber at a design-specific repetition rate and generating x-rays of sufficient energy and intensity to indirectly heat the DT capsule to ignition and burn. During burn, the target/RTL materials are irradiated by the energetic source neutrons and after burn, the debris is pumped out of the chamber for disposal or recycling. We examined two extreme irradiation approaches and assessed their impact on multi-disciplinary design requirements, such as the waste level, economics, and design complexity. The open-cycle, once-through approach irradiates the target/RTL materials a single time and then disposes of them in a repository. In the closed-cycle recycling approach, the target/RTL materials are remanufactured, spending a few days outside the chamber in an on-site factory, and reused for the entire life of the plant. The main goal of the latter approach is to lower the target/RTL inventory and minimize the waste stream at the expense of more radioactive end products and a more severe radiation environment at the target/RTL fabrication facility. Our results offer two divergent conclusions on the target/RTL recycling issue. For the HI concepts, target recycling is not a “must” requirement and the preferred option is the one-shot use scenario as target materials represent a small waste stream, less than 1% of the total nuclear island waste. We recommend using low-cost hohlraum materials once-through and then disposing of them instead of recycling expensive materials such as Au and Gd. On the contrary, RTL recycling is a “must” requirement for the Z-pinch concept in order to minimize the RTL inventory and enhance the economics. The initial activation results showed that the steel-based RTLs could meet the low level waste and recycling dose requirements with a wide margin when the RTLs are recycled for the entire plant life even without a cooling period. The incremental cost associated with the recycling scheme and the timeline of the remote remanufacturing process using robotic or similar technology should be investigated during the course of the Z-pinch power plant study.