The Reprocessing and Activation of Advanced Tritium Breeder Pebbles

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Introduction

Tritium Breeding for Fusion

Breeder Pebble Fabrication

Recycling Schedule

DT-reaction in plasma
\( D + T \rightarrow n + He \)

Time after shutdown (year)

Tritium breeding in blanket
\( Li + n \rightarrow T + He \)

Breeder Pebbles

(Li\( _2 \)SiO\( _3 \))

Breeder melt

Liquid Nitrogen

Recycling Schedule

Fabrication/
Reprocessing

Use in reactor
for 3 years

Storage until
remote level
(Waiting time: \( t_R \))

Remote level

Hands-on level

Reprocessing

In order to prove the viability of melt-based reprocessing, it must be possible to re-melt the used pebbles using the standard process while maintaining the original material properties

- A large batch of pebbles was produced using ultra-pure starting powders.
- The pebbles were then refilled into the crucible and reprocessed multiple times and analysed after each batch.

Simulation

- Averaged activation property of breeder pebbles (i.e. contact dose rate [Sv/h]) after single-use/multiple-recycling was calculated by MCNP and FISPACT code.
- Waiting periods for remote level and hands-on level (\( t_R \) and \( t_H \)) were estimated.

Conclusions

- Breeder pebbles can be successfully recycled using the melt-based process.
- Only elements found in the crucible alloy accumulate upon re-melting.
- Pebbles with depleted lithium levels can be re-enriched by re-melting the pebbles with additions of LiOH using the standard process.
- The reprocessing does not affect the pebble properties.
- Critical radio-nuclides have been specified.
- Multiple use of the breeder pebbles is feasible with a 22 year waiting period (\( t_R \)) even after 15 operation cycles.

These findings prove that melt-based, single stage recycling is a viable option for the reprocessing of breeder pebbles.