ENHANCED FABRICATION PROCESS FOR LITHUM ORTHOSILICATE PEBBLES AS BREEDING MATERIAL

M. Kolb[1], R. Knitter[1], U. Kaufmann[1], D. Mundt[2]

[1] *Karlsruhe Institute of Technology, Institute for Materials Research III, 76021 Karlsruhe, Germany*
[2] *Goraieb Versuchstechnik, 76227 Karlsruhe, Germany*

Corresponding author: matthias.kolb@kit.edu

The solid breeder blanket concept proposed by the European Union features the tritium breeding ceramics as pebble beds inside several breeder units. The pebble bed will not take part in the structural rigidity of a breeder unit. Still the pebbles need to withstand forces originating from thermal expansion mismatches and neutron irradiation. If a considerable number of pebbles break due to these forces, concerns have been raised that the fuel cycle of fusion power plants could turn inadequately efficient.
The European concept of the solid breeder blanket is designated to use lithium orthosilicate with a slight surplus of silica as breeding material. This material has been qualified over more than a decade and is routinely produced in small quantities for various experiments. It has been demonstrated that lithium orthosilicate can be processed by melt spraying, which provides an enormous advantage over sintering processes in terms of recycling [1,2]. Furthermore, lithium orthosilicate exhibits excellent tritium release properties compared to other solid breeder materials in discussion.
Recently published results of experiments made in the high flux reactor in Petten, NL showed that the current reference material of orthosilicate pebbles develops large cracks and a perceptible number of pebbles fail when subjected to fusion relevant neutron fluxes and temperatures cycles [3]. This is attributed to their relatively poor mechanical strength compared to other candidate solid breeder materials. To be able to benefit from the favorable properties of melt-sprayed lithium orthosilicate mentioned above, the current quality of pebbles has to be improved with regard to the mechanical properties.
The current quality of lithium orthosilicate pebbles exhibit large two- and three-dimensional defects like pores and cracks, originating from the fabrication process. It is therefore necessary to adapt the current production process to improve the pebbles' properties.
This work summarizes changes to the process and investigations of the current limitations that have to be overcome to enhance, not only, the mechanical properties of the pebbles, but also the yield of the process. A key feature of the improvements is to control the forming of the single pebbles more precisely than in the past. This has to be done in such a way that pores and other large defects are not introduced in the liquid and consequently into the pebbles. It also enables the size distribution of the pebbles to be more accurately controlled.
The pebbles produced by the modified process are characterized via SEM, X-Ray diffraction, Hg-Porosimetry, He-Pycnometry and optical microscopy for microstructure, phase analysis, and density. The pebbles are also mechanically characterized by single pebble crush load experiments, taking into account the pebble diameter, to evaluate the benefit of the changes.

This work was carried out within the framework of the EFDA Goal Oriented Training Programme WP08-GOT-EUROBREED.

[1] W. Pannhorst et al., Proc. SOFT20, 1998, 1441-1444.

[2] R. Knitter & B. Löbbecke, J. Nucl. Mater. 361, 2007, 104-111.

[3] M. Zmitko et al., ICFRM-14, 2009, to be published in J. Nucl. Mater.