Karlsruhe Institute of Technology

Institute for Applied Materials

DETERMINATION OF FRICTION COEFFICIENTS OF TRITIUM BREEDERS AND THEIR INFLUENCE ON PEBBLE BED MECHANICS

M. H. H. Kolb, R. K. Annabattula, R. Knitter, M. Kamlah

INTRODUCTION

The Helium Cooled Pebble Bed (HCPB) blanket developed in the European Union features pebble beds of slightly hyperstoichiometric lithium orthosilicate (LiOSi) and beryllium.
The pebble beds will most likely be strained during operation in a fusion reactor due to thermal expansion mismatches and neutron irradiation.
As relevant experimental investigation of the pebble bed response to strain is scarce and difficult to obtain, it is thus essential to model the pebble beds to predict their behavior.

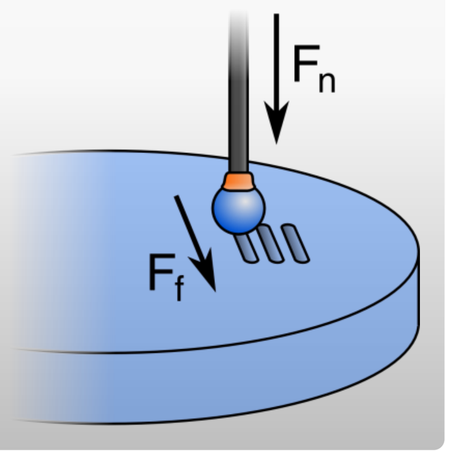
At KIT the micromechanical behavior of an assembly of spherical pebbles is studied using the discrete element method (DEM). It was recently shown that the friction coefficient between the individual pebbles significantly affects the calculated pebble bed behavior.
In order to achieve more realistic simulations of the pebble beds, the friction coefficient of lithium orthosilicate pebbles on lithium orthosilicate platelets and Eurofer were measured and the results are implemented in the model.

EXPERIMENTAL

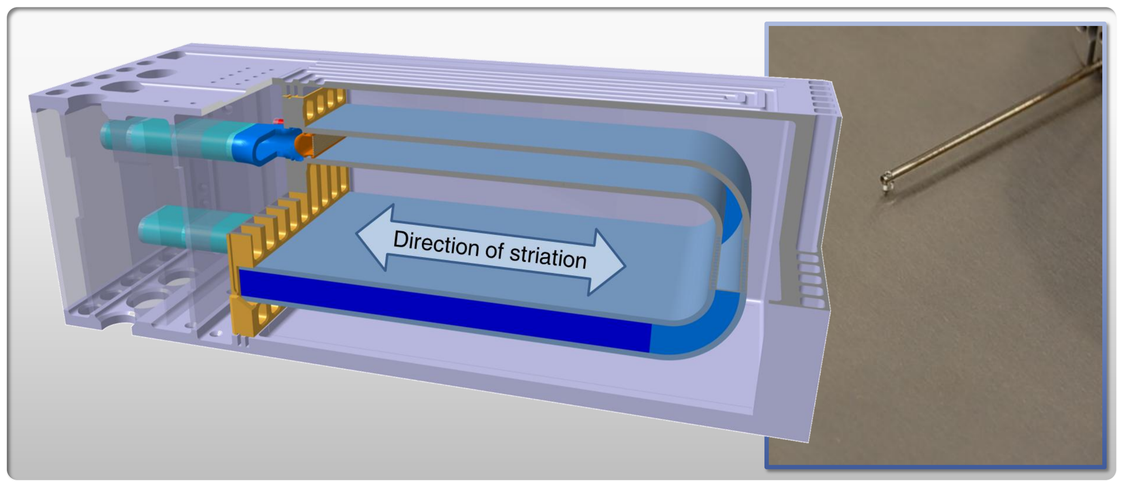
The friction measurements were carried out using a pebble-on-plate micro-tribometer, with the pebbles glued to cannulaes.
The lithium orthosilicate plates were specially prepared by sintering pellets from crushed pebbles.
The Eurofer plates used for the friction measurements were from the same grade that is going to be used to fabricate the breeder units of the EU TBM and shows distinct striation.

MEASUREMENT PARAMETERS:

Normal force:	0.5 – 1 N
Sliding velocity:	5 – 100 µm/s
Sliding distance:	100 – 1500 µm
Pebble diameter:	500 – 600 µm
Cannula gauge:	500 µm
Atmosphere:	Ambient air



The performed measurements took the striation into account.
The DEM model considers a cube with periodic boundary conditions that is filled with 5000 randomly placed 500 µm spheres filling 63.4% of its volume. This assembly is uni-axially compressed to 1.5% strain while the stress is calculated.
Two different calculations were performed, one allowing the pebbles to break once their crush load is exceeded.



RESULTS & OUTLOOK

The measurements showed no perceivable breaking away from static friction into dynamic friction, thus simply one value describes the friction between two pebbles. Typical wear of the surfaces and measurements can be seen on the right.

- The system displays stiffer response with increase in friction coefficient due to the large amount of energy needed to move the pebbles with large friction
- The crushable assembly exhibits max. stress levels closer to former uni-axial compression experiments than the non-crushable assemblies. Quantitative comparison with these experiments has still not been achieved, however, the result shows the trends observed in the experiments
- It has been shown that the friction coefficient of LiOSi-on-LiOSi pebble interaction shows significant influence on the mechanics of pebble beds
- When using a normal distribution for the friction coefficient (mean: 0.26) the results are similar to the case of μ=0.3

The influence of the atmosphere on the friction behavior has to be investigated and polydisperse pebble assemblies have to be considered in the future. Also the friction coefficient on Eurofer has not been considered yet.