THERMO-MECHANICAL SCREENING TESTS TO QUALIFY BERYLLIUM PEBBLE BEDS WITH NON-SPHERICAL PEBBLES

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Objectives

- In present ceramic breeder blankets, pebble-shaped beryllium is used as a multiplier. As candidate material, spherical pebbles with diameters of \( d = 1 \text{mm} \) are considered.
- Non-spherical particles are of significant economical interest. Except of packing factors\textsuperscript{1}, no thermo-mechanical pebble bed data exist for non-spherical beryllium grades.
- Qualification tests were performed in helium atmosphere at ambient temperature: Uniaxial Compression Tests (UCTs) combined with the Hot Wire Technique (HWT) to measure the thermal conductivity \( k \).

Experimental

Investigated beryllium grades:
- Be-1: spherical 1mm pebbles, NGK, Japan
- Be-A, Be-C: 2.5mm pebbles, different grain sizes, Bochvar, Russia
- Be-D: 2mm pebbles, Materion, USA

UCT and HWT experimental set-up: Only \( \approx 120 \text{cm}^3 \) of non-spherical beryllium grades were available. This resulted in a small set-up with a somewhat reduced measurement accuracy, ‘screening tests’. Therefore, the comparison with the spherical beryllium pebbles was important.

Hot Wire Modelling

The HWT Technique is a standard technique for thermal conductivity \( k \) measurements of materials with low \( k \) values in large containers. Both requirements are not fulfilled in the present case. Therefore, a detailed modelling of the HWT is required for the interpretation of the HW signal.

Experimental Results

\[ t* = \log t \]

a) 3-D transient analyses with the FE ANSYS code were performed modelling in detail the HW (with inner structure) and the container.

b) A nominal value for the pebble bed thermal conductivity has been assumed, and then, the measured curve is approached by varying the HTC at the HW and the container walls. After a first period of time, the slope of an ideal HW temperature curve becomes constant (half-log plot). This is not the case for both the measured and calculated signal.

c) Because of the varying slope, the measured and calculated values of \( k \) are not constant. As correct value \( t^* \) that value is taken where measured and calculated values agree (iteration process)

d) This procedure is carried out for different values of \( k \) and a calibration curve is obtained. Different curves are determined for spherical and non-spherical pebble beds.

Conclusions

- Compared to spherical pebble beds, the thermal conductivity for non-spherical pebble beds is lower caused by i) the softer bed behaviour (smaller stress \( s \) for a given strain \( \varepsilon \) value), and, ii) the generation of smaller contact surfaces because of the non-regular shape.
- For blanket operation, the pebble bed strain is the primary parameter; for softer pebble beds the anticipated increase of the thermal conductivity during heating-up is smaller because of the reduced build-up of thermal stresses.