Two-scale thermal shock damage analysis in refractory ceramics

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Introduction

Refractories are used to build structures subjected to high temperatures, such as the metallurgical furnace linings in metal, glass and ceramic manufacturing industries. These structures are highly sensitive to damage due to thermal shock, which is basically cracking, stemming from rapid temperature changes. At the meso level, non-uniformity in thermal expansion and/or mismatches between the constituents results in microcracking.

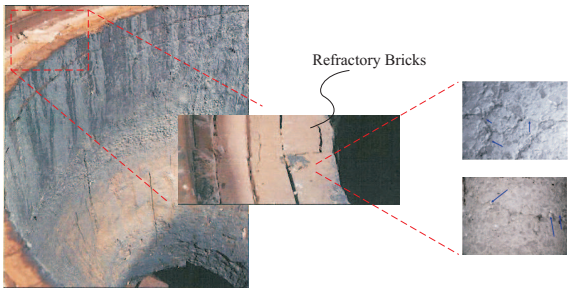

Fig. 1 *Typical refractory material microstructure.*

Objective

The goal of this contribution is to construct a meso level model to be used within a two scale thermomechanical analysis framework based on computational homogenization [1], which has been presented in the previous posters.

Modeling

At the meso level, the material microstructure is idealized as grains embedded in a matrix with certain volume fractions. The diffuse microcracking taking place within the matrix is modeled by the well established continuum damage mechanics (CDM) approach and the interfacial damage is introduced through thermo-mechanical cohesive zone elements.

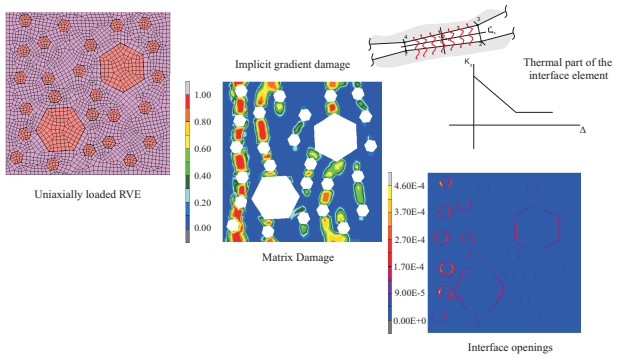

Fig. 2 *RVE under uniaxial loading.*

As seen in figure 2, incorporated mechanisms capture the localization band and the interfacial damage sufficiently well. To calibrate the damage and interface models, the thermal shock tests (figure 3) conducted by Corus CRC, are used.

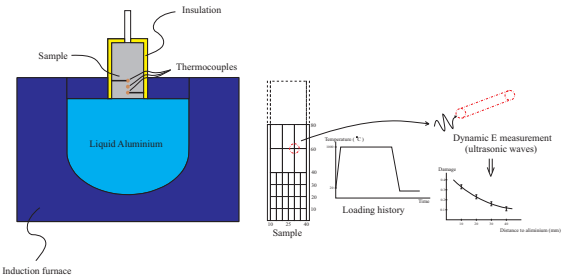

Fig. 3 *Thermal shock test set-up and sample with the measurement grid, reproduced from [2].*

For the samples used, the principle of scale separation does not hold due to very steep temperature profile and RVE size. Therefore, the sample is modeled in detail as shown in figure 4.

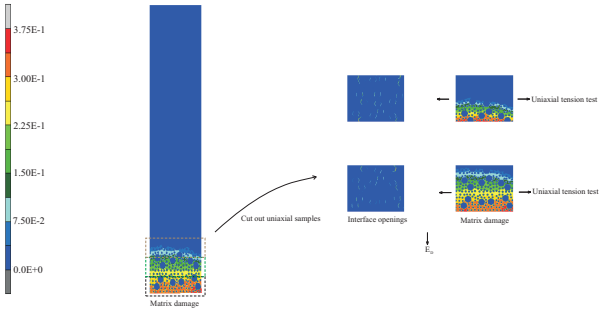

Fig. 4 *Calibration of the model parameters.*

Future Work

After determining the model parameters, the meso level model will be used within a two-scale computational homogenization framework [1], to investigate the thermal shock response of more realistic refractory structures.

References:

[1] Özdemir I., Brekelmans W. A. M., Geers M. G. D.: *FE^2 Computational Homogenization for thermomechanical analysis of solids* (C.M.A.M.E., accepted)

[2] Damhof F., Brekelmans W. A. M., Geers M. G. D.: *Experimental analysis of the evolution of thermal shock damage using transit time measurement of ultrasonic waves* (J.E.C.S., accepted)