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Strength of Porous Ceramics – Mechanical Testing and Numerical Modelling

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ABSTRACT

The lecture addresses modelling of the damage of porous ceramics on the microstructural level, and the failure of structural components. The research has been occasioned by the industrial interest in the strength of ceramic filter supports used in nanofiltration, where internal pressure is of importance. Porous ceramics subjected to fluid pressure in the pores are prone to brittle microfracturing which may progress to brittle or quasi-brittle rupture of the component. Apart from physical and numerical modelling on the microscale, subtle laboratory testing of components has been of paramount importance; brittleness suggests statistical evaluation. The study focuses on mechanical issues, but conceptual thoughts on stress-enhanced corrosion are included [4]. The phenomenon is significant to aging which determines the life-time of parts exposed to chemically aggressive media.

A brief discussion on the formalism for the fracturing continuum [1] is followed by the modelling of cracking by separation of grain boundaries. The associated algorithm simulates progressive damage on artificial microstructures generated in the computer for given material characteristics [2], and determines rupture statistics in dependence of various parameters. Laboratory measurements on the structural parts of interest (circular cylinders with longitudinal channels) refer to the diametral compression (Brazilian) test which adequately replaces the condition of channel pressure [3], as justified by finite element stress analysis. The impact of the two loading cases on Weibull statistics is formally explained, effects of basic material and doping on component rupture are investigated, the damage tolerance confirmed, corrosion discussed. Synthesis incorporates material strength statistics in the finite element model and estimates critical locations in the structural part under internal pressure. There is quantitative agreement with pressure levels actually registered at rupture. The account refers to cooperative research performed at the Universities of Stuttgart and Caen [4].

References

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