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DEVICE FOR PROCESS CHARACTERIZATION OF CERAMIC MATRIX COMPOSITES FABRICATED BY LIQUID INJECTION

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Nowadays, ceramic materials are used in many industries. Ceramic materials are well known by their high strength and excellent thermal and chemical stability. In addition, most of ceramics retain acceptable mechanical properties at temperatures higher than 1000 C. However, the low impact toughness of these materials limits their use in industries such as aerospace. The porous nature of the material allows cracks to propagate with low energy thus making the material susceptible to brittle fracture. Ceramic Matrix Composites (CMC) have been developed to combine the advantages of bulk ceramics, their low density and their excellent mechanical properties at elevated temperatures, with the advantages of fiber reinforced composites offering better tolerance to damage. Thus, making possible the use of CMC in environments requiring some high mechanical properties at elevated temperatures and at a high level of confidence.

An approach to create such a material is to generate a Weak Matrix Composite (WMC). This method proposes to control the residual porosity of the matrix to improve the impact properties. WMC is particularly applicable to Oxide/Oxide CMC since conventional manufacturing methods inevitably leave a high matrix porosity distribution (in the order of 20 to 30% of the total volume ratio). However, obtaining a matrix microstructure with fine and evenly distributed pores remains hard to achieve with the actual fabrication processes typically used in the industry. This is due to the heterogeneous nature of the ceramic particles used in liquid molding of CMC.

In this work, a novel slurry impregnation and filtration method was developed to fabricate Oxide/Oxide CMC. This method consists of a transverse impregnation of the fibrous reinforcement, which results in a quicker filtration than typical in-plan impregnation. Due to the though-thickness filtration and compaction, this process results in composites with higher density and lower residual porosities than traditional processes.

In this study, an instrumented device has been developed to characterize the through-thickness impregnation of ceramic fibers by a slurry filled with ceramic particles. The device, based on the principle of Darcy's column, integrates flow measurements, pressure and displacement control and filtration measurements. This instrument was first used in the present work to characterize the permeability of the fibrous reinforcement and filtration media. It was then used to study the formation of the ceramic cake by filtration of the ceramic particles. Slurries containing different concentrations of alumina particles were filtered under different pressure conditions to optimize the cake formation and filling of fibrous reinforcements with the lowest porosity. Furthermore, a mathematical model based on Darcy's law was developed in this study to predict the rate of filtering and cake formation during injection using the permeability and filtration data measured with the experimental device. This mathematical model allows to predict the filtration time needed to produce a densified CMC with good accuracy

References

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