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CMAS deposition within the turbine of a small jet engine and effects on TBC spallation

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CMAS DEPOSITION WITHIN THE TURBINE OF A SMALL JET ENGINE AND EFFECTS ON TBC SPALLATION

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The deposition characteristics of ingested CMAS (in the form of volcanic ash) have been studied using a small turbojet aeroengine. The particulate was fed into the air intake at a controlled rate. Deposition on internal surfaces within the turbine was investigated using an optical fibre borescope. Deposition mainly occurred on the nozzle guide vane leading edges and the blade platform. It did not occur to any significant extent on rotor blades. A simple numerical model was used to predict particle acceleration and heating in flight. The predictions highlight the importance of particle size. It is both observed and predicted that relatively large particles (~100 µm diameter) are more likely to adhere than smaller ones. Their greater inertia makes them more likely to impact on surfaces than finer ones and, while their temperature at that point will probably be below that at which they become soft, the difference is likely to be small (since such ashes often exhibit very low T_g values). In conjunction with the surface temperature being somewhat higher than T_g, adhesion of such particles is a probable outcome. Particles of even larger size probably would not adhere (because they were too cool), but ingestion of such powder is not very likely.

Investigations have also been carried out into the effect of CMAS on sintering-induced spallation of plasma sprayed zirconia TBCs. Selected loadings of vermiculite (VM) powder were introduced onto the surface of free-standing coatings, followed by heating (up to 1500°C) for periods of up to 80 h. The presence of CMAS can induce various microstructural changes in the TBCs and also accelerates the rise in their (in-plane) Young's modulus. Finally, results are presented concerning the effect of VM on spallation resistance, using coatings sprayed onto dense alumina substrates. The thermal misfit strain induced during cooling has a magnitude similar to that for YSZ on a superalloy and, since little change occur in the interfacial structure, spallation arises solely from TBC sintering. In particular, it was found that spallation lifetimes can be substantially reduced by VM, even at relatively low levels (~1 wt.%). This is related to acceleration of the sintering-induced increases in TBC stiffness. Penetration of CMAS-type particulate thus has the potential to impair substantially the thermo-mechanical stability of zirconia TBCs.