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DEVELOPMENT OF A NATURALISTIC TEST MEDIA FOR DUST INGESTION CMAS TESTING OF GAS TURBINE ENGINES

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A test media for dust ingestion testing of gas turbine engines was desired so that effects similar to those found in fielded vehicles could be produced in a laboratory setting. The effort to produce an effective test media required preliminary work on several aspects of dust ingestion behavior in gas turbine engines that had not previously been examined. Impact erosion features in the cold sections and the formation of calcium magnesium aluminosilicate-like (CMAS-like) glassy deposits in the hot sections of engines needed to be in concordance with the chemical and physical characteristics of natural sands and dusts that have or could be ingested during operation. This talk will focus on the composition of the AFRL02 and the related AFRL03 test media that are now being used for some engine dust ingestion testing. AFRL02 was designed to form a CMAS-like deposit in static laboratory tests whereas AFRL03 was designed to provide some erosion of cold sections and form CMAS-like deposits in hot sections during full-scale rotating engine tests. Neither of these materials is sized like a desert dust. These test media were developed by applying the standard geoanalytical technique of mineral modal analysis to the composition of natural engine deposits. Mineral modal analysis was then combined with actual mineral compositions of desert sands and dusts to design a naturalistic test medium. The resulting mixture was compared to natural dusts using differential scanning calorimetry (DSC) for melting behavior. The microstructure of deposits melted onto yttria-stabilized zirconia thermal barrier coating (TBC) test buttons were compared by secondary electron and back-scattered electron microscopy. Elemental mapping of the co-fired manufactured test medium demonstrated penetration into physical vapor deposited (PVD) zirconia TBC similar to that produced by a natural CMAS-forming comparison dust. Testing TBCs for their compatibility or resistance to attack by CMAS in engine tests should use materials that will behave in ways similar to materials from the natural environment. The value of AFRL02 and AFRL03 test dusts is that they should perform in a similar manner no matter where they are produced and no matter who produces them. A commercial source for these materials is Powder Technology Inc. of Burnsville, Minnesota, USA. The specified mineral compositions and particle size ranges for these media should make them amenable to compounding by the end-user or by a local producer. There will be no one correct test material for creating CMAS deposits, but the use of test media that behave in a uniform and predictable manner and behave like natural material will allow faster development of better performing TBC protective systems. This work was supported in part by the Office of the Secretary of Defense, the U.S. Air Force, the U.S. Navy, and the U.S. Army.