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PREDICTION OF THE CYCLIC DURABILITY AS A FUNCTION OF CYCLE DURATION AND TEMPERATURE OF AN AIR PLASMA SPRAYED COATING USING INELASTIC STRAIN

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Abstract: A detailed study of the failure mechanisms in an APS TBC was carried out involving over 1000 micrographs. As a result the kinetics of oxidation and rumpling were characterized. In addition it was found that the failure was always within the ceramic caused by progressive cracking. At approximately half the spallation life, crack linking became the dominant growth mode for cracks. This pattern of damage remained constants over the temperature range of 1066 °C to 1149 °C and for cycle durations of 0.5 hours to 50 hours. The change in temperature resulted in a variation in spallation life of a factor of 5 and the variation in hold time resulted in a variation in life of a factor of 7 and for the entire data set the ratio of the longest failure life to shortest was 17. Through the use of a finite element analysis (FEA) that used an experimentally validated viscoplastic model driven by imposed shape changes derived from measured oxidation and rumpling behavior as well as thermal expansion mismatch, the hot and cold inelastic strains were predicted and used to predict failure. It was possible to predict the entire data set using data from only two cyclic life tests at two different test conditions. The life as a function of temperature can be predicted from two experiments run with two different hot times at a single temperature. The life as a function of hold time can be predicted from tests run at two temperatures at a single hold time. This suggests that the hold time dependence and temperature dependence are closely tied to the factors controlling inelastic strain. The inelastic strains can be determined form a combination of measured and computed behavior. It was also found that the finite element results can be captured without running the FEA using simple expressions that are calibrated using a large set of FEA runs.