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The stress development considering the creep-plastic behavior of TBCs during cooling stage

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Thermal barrier coatings are refractory, anti-oxidation and corrosion resistance, mainly applied on aero-engine hottest parts. The spallation failure of TBCs during service process can restrict the engines lifetime. The stress state, as the main reason of TBCs failure, is significantly influenced by the non-linear behavior of TBCs materials (e.g. plastic deformation and creep). Therefore, the accurate description of the non-linear behavior of TBCs materials is crucial in stress evaluation. Various constitutive models have been applied for stress prediction in previous researches. However, only the plasticity or creep of TBCs materials is considered, which can lead to obvious difference in stress prediction. Based on a creep-plastic constitutive model, this work studies the effects of the creep-plastic behavior of bond coat and thermally grown oxide on the stress development during cooling stage. Different from the conventinal plastic or creep constitutive models, this creep-plastic model reveals that the stress can be identified in three sections when BC creep properties varies in wide margins: Section I is a plasticity period with small BC creep rate, in which plastic mainly affects the stress state, in section II with medium creep rate, both creep and plasticity affect the stress development in section with a larger creep rate, the creep becomes the main factor controling the relaxing process. Meanwhile, it is found that if creep in TGO is considered, the stresses are overall relaxed no matter if BC is plastic, creep or creep-plastic.

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