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Editorial

Editorial on Thermal Barrier Coating

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THERMAL BARRIER COATINGS

Thermal barrier coatings (TBCs) are advanced materials systems used to control exhaust heat on metallic surfaces that operate at high temperatures, such as gas turbine or aero-engine components. These thermally insulating coatings range in thickness from 100 m to 2 mm and can withstand a significant temperature difference between the load-bearing alloys and the coating surface, protecting components from high and sustained heat loads. These coatings can allow for higher operating temperatures while limiting structural component thermal exposure, thereby extending part life by reducing oxidation and thermal fatigue. TBCs allow working fluid temperatures higher than the melting point of the metal airfoil in some turbine applications when used in conjunction with active film cooling. There is considerable incentive to develop new and improved TBCs due to growing demand for more powerful engines operating at higher temperatures with better durability/lifetime and thinner coatings to minimise parasitic mass for rotating/moving parts. TBC material requirements are similar to heat shield material requirements, but emissivity is more important in the latter application. To perform well in hostile thermo-mechanical conditions, a TBC must meet certain specifications. Adequate porosity, as well as sufficient matching of thermal expansion coefficients with the metal surface that the TBC is coating, are needed to deal with thermal expansion stresses during heating and cooling. Significant volume changes (which occur during phase changes) may cause the coating to crack or spall, so phase stabilization is necessary. Oxidation resistance, as well as good mechanical properties for rotating/moving parts or parts in contact, is needed in air-breathing engines. As a result, the general criteria for a successful TBC can be summarized as follows:

1) A melting point that is extremely strong.

2) There is no phase transition between room and operating temperatures.

3) There is a lack of thermal conductivity.

4) Chemical inertness is a fourth factor to consider.

5) The metallic layer has a similar thermal expansion.

The metal substrate, metallic bond coat, thermally-grown oxide (TGO), and ceramic topcoat are the four layers that make up a thermal barrier coating. The ceramic topcoat is usually made of Yttria-Stabilized Zirconia (YSZ), which has a low conductivity and is stable at the nominal operating temperatures used in TBC applications. The bond coat is an oxidation-resistant metallic coating that is directly applied to the metal substrate. It is usually 75-150 m thick and made of a NiCrAlY or NiCoCrAlY alloy, though other Ni and Pt aluminides bond coats are also available. The bond coat's primary function is to protect the metal substrate from oxidation and corrosion, particularly from oxygen and corrosive elements. The bond coat's main job is to protect the metal substrate from oxidation and corrosion, particularly from oxygen and other corrosive elements that pass through the porous ceramic top coat. The formation of a thermally-grown oxide (TGO) layer occurs when the bond-coat is oxidized at temperatures above 700°C, which is used in gas-turbine engines. For many high-temperature applications, the formation of the TGO layer is unavoidable, so thermal barrier coatings are often constructed so that the TGO layer grows slowly and uniformly. The structure of such a TGO would have a low diffusivity for oxygen, allowing metal diffusion from the bond-coat to regulate further growth rather than oxygen diffusion from the top-coat.

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