Thermal Barrier Coating

In Aerospace, the demand for improved performance in high-temperature mechanical systems has led to increasingly harsh operating environments, particularly for the components in advanced gas-turbine engines. Future improvements in gas-turbine performance will require even higher operating efficiencies, longer operating lifetimes and reduced emissions. Achieving these requirements will necessitate still further increases in the gas inlet temperatures and consequently, the development of structural materials inherently capable of higher temperature performance. Advanced cooling schemes coupled with Thermal Barrier Coatings (TBCs) can enable the current families of super alloy components to meet the materials needs for the engines of tomorrow.

Thermal-barrier-coating systems are currently capable of providing metal temperature reductions of up to about 140 deg C, whereas potential benefits are estimated to be greater than 170 deg C. The use of TBCs in combination with cooling schemes has enabled the operation of gas-turbine engines having combustion gas temperatures in excess of 250 deg C above the melting temperature of the super alloy component (e.g., early stage turbine blades and vanes). Moreover, the use of TBCs at lower operating temperatures reduces the metal temperature, which in turn increases the service life of the component.

Characteristic of TBC

- Applied and used in hot gas engine environment on metal, their role is to protect the engine components in the hot gas path from the effects of the operating temperature.
- An aero TBC is a zirconia-yttria (or other zirconia based) ceramic on a metallic MCrAlY bond coat over a superalloy. MCrAlY coatings (where M = Co, Ni or Co/Ni) are widely applied to first and second stage turbine blades and nozzle guide vanes, where they may be used as corrosion resistant overlays or as bond-coats for use with thermal barrier coatings.
- Because of temperature, a build up of a layer called thermally grown oxide (TGO) is generated between the ceramic layer and the bond coat. This is due to the oxidation effect of the bond coat during oxidation and thermal shock. The TGO is to hinder the process of oxidation of the bond coat.
- TBCs are for metallic substrates and provide thermal protection. The TBC top coat is in compression.
- TBCs have better strain tolerance.
- The major trigger of failure in thermal barrier coating is the stresses, they generally initiated by bond coat oxidation, bond coat surface irregularities, yttria stabilized zirconia (YSZ) phase transformation, and YSZ sintering
- TBC layer thickness is 1–1.5 mil bond coat, 3–4 mil top coats

The limitation are TBC do not provide self-renewing protection, when they spall the thermal protection is lost. There are currently no effective methods (e.g., non destructive evaluation) that can act as quality control and/or monitor for TBCs. Life prediction for TBCs is not as accurate as is needed.

References

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