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Challenges in the development of thermally sprayed self-healing thermal barrier coatings

Abstract:

Thermal barrier coatings (TBCs) are widely used to protect components operating in the aerospace industry, which are exposed to exceptionally demanding service environment. Their durability and thermal properties play a critical role in prolonging turbojet's components lifetime. However, continuous advances in TBC technology are needed to meet the increasingly demanding service conditions and more aggressive degradation mechanism throughout the service life of TBCs. Consequently, the development of self-healing coatings, capable of autonomously repairing microcracks and restoring their protective function, has emerged as a promising strategy for extending coating lifetime and improving the reliability of advanced aerospace systems. Self-healing mechanisms are achieved in TBCs by introducing a healing agent into the ceramic topcoat coating structure, which introduces additional challenges related e.g. to the coating process.

This work discusses the key challenges associated with the development of plasma-sprayed self-healing TBCs, starting from the selection of a suitable healing agent and with particular emphasis on form, morphology and distribution of the healing agent, as well as how healing agent should be introduced into the coating and incorporated into the thermal spraying process. Another difficulty is determining the appropriate amount of healing agent, which should be carefully selected, to ensure that it does not weaken the coating structure and its thermomechanical performance. While self-healing mechanism in TBCs is based on oxidation reaction, the healing agent should be protected from high temperatures, premature oxidation, decomposition, or other reactions during thermal spraying. The introduction of new thermal barrier materials may require the individual adjustment of the healing agent to ensure chemical compatibility, appropriate activation conditions and effective healing of thermally induced damage.

Understanding these challenges is essential for developing thermally sprayed TBCs capable of autonomously repairing damage and extending their service lifetime under high-temperature operating conditions.