Chapter 8

Slurry Sprayed Mullite Coatings and Their Corrosion Performances

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ABSTRACT

Slurry spray technique (SST) is a distinctive variant among the numerous and already established coating techniques. Functionally graded thermal barrier and environmental barrier coating have been the functionalities developed so far for the process. Among the choice of the various ceramic feedstocks available mullite and partially stabilized zirconia have been found suitable and investigated for the coating deposition via SST. This chapter reports the findings of the corrosion studies in simulated industrial corrosive environments and characterization results of the six sets of slurry sprayed mulite-nickel based coatings. Decent protection against coating has been found during the immersion test performed on these coatings for evaluating their corrosion performance. The developed coatings are recommended for use in applications to endure the elevated temperature and inflict corrosion. Thermal cycling test was performed to support the acceptable thermal shock resistance and coating compliance of the developed coatings.

INTRODUCTION

Surface coatings are pursued as a protective agent applied to all or part of the substrate for the functional purpose intended. Environmental barrier coatings (EBCs) are pursued in the structurally critical components of the turbo-machineries to improve the stability and service life of the substrate material wherein the components are exposed to elevated temperature and corrosive environment. EBCs have
been used as “prime reliant” coatings since they serve as surface protection against combustion species containing water vapour to inhibit chemical reactions at the underlying substrate (Bezzi, et al., 2010).

In order to enhance the performance and efficiency, there have been increasing attempts over the past decades to raise the working temperatures of the turbomachinery (Walston, 2004). The areas in focus to the EBC application could include the components of combustion turbines, internal combustion engines, boilers, and waste incinerators etc., wherein the parts are exposed to the high temperature above 150°C and under oxidative environment. More EBC applications include aeronautical, nuclear, automotive industries and aerospace engine components like vanes, rotors, blades, combustor liners, shrouds, transition ducts and turbo airfoils.

Recent work by the authors has investigated mullite-nickel based slurry sprayed coatings fabricated with the aid of TiO₂ as liquid phase sintering additive and fly ash as a ceramic substitute (Verma et al., 2016a, 2016b, 2016c). The results confirmed that SST is a propitious alternative to the existing sophisticated techniques. Comparable performances have been reported in adhesion strength and coating thickness during these studies. It is therefore of interest to extend the scope of investigations to these developed SST coatings. The integrity and durability of the developed coatings shall be contingent on the evaluation of their use at elevated temperature. With these views, an attempt has been made to inclusively evaluate the longevity in context to the corrosion behavior, since no such information on these grounds could be found in the scientific literature. Small-scale laboratory studies which can provide a broad range of coating compliance data is a cost effective alternative to full-scale testing. The present contribution combines the observations described in previous reports by the authors (Verma et al., 2016a, 2016b, 2016c) and provides a new analysis based on the corrosion behaviour.

**BACKGROUND**

Over the past three decades, many fabricating methods have been developed for depositing ceramics and other coating materials on a metal substrate. All these fabricating techniques can be categorized into three main groups: deposition techniques, flame spray techniques, and bulk processes (Kieback et al, 2003). Each fabrication method differs from each other considerably, in the context of physical principal utilized, cost, and intricacy. However, the main hindrance in the pervasive utilization of these techniques is the sophisticated equipment and thus manufacturing cost involved. Besides, most of these already established fabrication methods have not been effective in large curved areas. Despite, the existence of pre-established and consolidated deposition techniques, an active research fraternity strives for novel and cost-effective alternatives, both for the method and feedstock materials. Moreover, the use of low fabrication cost stages and the possibility to utilize the industrial waste makes it easy to imagine the potential material and cost saving offered by SST. Slurry spray technique (SST) is conceived to be as an analogous to the thermal spray coating regime, because of the use of thermal energy required for sintering of the powder constituents. SST being relatively facile and unutilized deposition technique requires supplementary research efforts for it to make commercially viable.

ASTM 1018 low carbon steel have properties close to iron based super-alloys used for gas turbine parts like diffuser, compressor, mixer & exhaust which are subjected to relatively lower temperatures (Goward, 1998). Moreover, EBCs on economic materials like low carbon steel have the potential to replace the costlier materials like Ti-based alloys and Ni-based alloys used in steam turbine and other turbomachinery components. These parts are supposed to be used at relatively low cycle fatigue (LCF)
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