Ceramics International xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Ceramics International

journal homepage: www.elsevier.com/locate/ceramint

Effect of powder particle size on vibration damping behaviour of plasma sprayed alumina (Al_2O_3) coating on AISI 304 stainless steel substrate

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ARTICLE INFO

Keywords:
Alumina (Al_2O_3)
Coating
Air plasma spraying
Damping capacity
Microstructure

ABSTRACT

The damping capacity of plasma sprayed alumina (Al_2O_3) coatings on AISI 304 stainless steel was investigated in this study as a function of particle size of the starting alumina powder. The coatings were prepared from different sizes alumina powder using commercial air plasma spraying (APS) technique. The damping properties of coated samples were characterized by damping capacity (Q^{-1}) measured experimentally using dynamic mechanical analyzer (DMA). The surface morphology of the coatings was studied using scanning electron microscope (SEM). The results revealed that the coating was porous and was able to improve the damping capacity of bare substrate. It was also observed that the powder particle size had a significant effect on the damping characteristics of the coatings. The damping values were found to be increased with the increase in particle size in the measured strain range. This behaviour was correlated with the microstructure investigated by SEM.

1. Introduction

Plasma spraying is preferred to grow the thick protective coatings in a less time due to its high deposition rate [1]. This protective coating is mainly carried out for chemical resistance, wear resistance, thermal resistance, and corrosion resistance etc. [2]. Wide verity of materials (such as metals, alloys, ceramics, polymers and composites) can be coated with plasma spray technique [3].

Plasma sprayed alumina (Al_2O_3) coating is found its application in high temperature, wear resistance, corrosive resistance environment [4]. There are many parameters that can affect the quality of the alumina coating [5,6]. It is important to study the properties like mechanical, physical, coating adhesion strength [7]. Because, many load carrying structures, such as aircraft gas turbine engines blades, typically operate under high temperature, pressure, shock, etc. [8] in such conditions they are exposed to thermal vibration that shorten the service life [9]. To prevent such failure, the excited vibration response needs to be studied and analysed with respect to the damping properties and dynamic mechanical performance. The DMA evaluates the damping behaviour of materials in different loading condition [10].

Several works have been reported about the study of vibration damping behaviour of several bulk materials, composites and polymers [11–16]. However, the reports on study of vibration damping behaviour of coatings in particular on ceramic coatings are scarce in literature [17–20]. As described aforesaid that alumina coating is a potential candidate for many state of art applications due to its superior mechanical and tribological properties and it is well studied and documented in literature. Nevertheless, the damping behaviour of alumina coating not yet explored in the reported literature.

Therefore in the present study, for the first time in-depth damping behaviour of plasma sprayed alumina deposited on AISI 304 stainless steel is investigated. The effect of starting alumina powder particle on damping behaviour of coatings is also studied in the present work.

2. Materials and deposition of coating

The alumina powder was deposited on AISI 304 stainless steel substrates of dimension 45 × 10 × 1.6 mm^3 by APS technique. The chemical composition of AISI 304 stainless steel substrate is summarized in Table 1 received from supplier. To avoid powder dispenser and/or torch blockage problems, i.e. to achieve smooth powder flow, the powders must be clean, carefully dried and vacuum-degassed before using them, often a heated powder hopper is also employed. Commercially available alumina powders were procured and were sieved to get proper particle size range with the help of a sieve shaker machine by using laboratory test sieves of ASTM C136 standard. The particle size range the powders considered in the study, segregated in the sieving operation are 10–40 μm, 53–75 μm and 74–106 μm. The mechanical properties of AISI 304 stainless steel substrate and alumina powder are given in Table 2 received from the suppliers. The substrates were

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http://dx.doi.org/10.1016/j.ceramint.2017.09.153
Received 26 July 2017; Received in revised form 7 September 2017; Accepted 19 September 2017