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Understanding the dry sliding wear behaviour of atmospheric plasma-sprayed rare earth oxide coatings

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ABSTRACT

In this paper, the friction and wear behaviours of Yttria Stabilized Zirconia (YSZ) coatings; Lanthanum Zirconate (LZ) coatings and Inconel 738 base material (BM) sliding against a sintered tungsten carbide surface were studied and compared under unlubricated conditions. Sliding experiments were performed in a pin-on-disc configuration. Further, relationships among porosity, normal load and disc speeds with respect to wear loss were derived by using the response surface methodology, and the wear mechanisms were discussed adequately. It was found that the wear resistance of the ceramic coatings gets deteriorated with the increase in the percentage volume of porosity.

1. Introduction

Ceramic materials with high hardness and high resistance to thermal and corrosive conditions and with relatively low densities offer many advantages over metallic and polymeric materials. Thermal spray coatings made out of oxide ceramics such as alumina, zirconia, titania, chromia and silica have been used widely as surface coating materials to improve resistance to wear, erosion, cavitation, fretting and corrosion. Because of their excellent properties, which are not available from metallic and cermet coatings, oxide coatings prepared using thermal spray processes have been widely used in the US Navy systems and in other industries [1]. Within the oxide coating materials, zirconia based ceramics have been extensively considered for engineering applications. Zirconia has been considered to be a good candidate coating material for high-temperature applications on account of its superior properties such as low thermal conductivity, high thermal expansion coefficient, high toughness, good chemical and dimensional stability, high melting point, high wear resistance, low density, high hardness, stiffness, strength and refractoriness [2].

Zirconia based coatings have been used in aero engines and internal combustion engines as thermal barrier coatings to enhance thermal efficiency, to increase their service life, for improved fuel economy and for thermal protection. Zirconia based coatings have been used to reduce emission and cooling requirement and to increase the wear resistance, corrosion resistance and the service life of the components [3]. In aerospace applications, these coatings are applied on to transition pieces, combustion lines, first-stage blades, vanes, space shuttle exhaust systems, rocket nozzles, high-temperature rings, bearings, bushings and seals [4]. In the case of internal combustion engines, these coatings are applied on piston crowns, cylinder heads, valve faces, cylinder liners, piston rings, exhaust valve faces and cylinder head fire decks [5]. Plasma spraying is versatile; practically, all materials that can be melted without decomposition can be deposited as coatings on virtually all reasonably heat resistant substrates [6,7]. Hence, the plasma spray method is the most widely used technique to produce a considerable variety of zirconia based coatings, which show favourable tribological behaviour, high antiwear resistance and ease of lubrication, owing to the oil storage of the pores in the coating [8,9]. The friction and wear characteristics of plasma-sprayed zirconia coatings are greatly affected by compositional and microstructural features, like microcracks, porosity, morphology and distribution of additions [10]. The wear mechanisms of zirconia based ceramic coatings are complicated due to the anisotropic nature of the coatings and the complexity increases further with the change of wear factors such as load, sliding speed, etc. Hence, in this paper, an attempt has been made to study the dry sliding wear behaviour of the state of the art thermal barrier material Yttria Stabilized Zirconia and Lanthanum Zirconate an emerging thermal barrier coating material, using a pin-on-disc wear test apparatus. Empirical relationships were derived using response surface methodology to study the effects of porosity, applied load and sliding speed

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