Chapter 4
Thermal Sprayed Coatings and Their Wear Characteristics

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ABSTRACT

Severe wear is the root cause for the failures of components, which resulted in the loss of functionality and dimensional accuracy of systems. An estimation of durability and reliability of components is governed by failure analysis under rigorous operational environments with a range of wear mechanisms. The researchers have two ways to minimise the wear: either develop new anti-wear materials or improve wear resistance of existing materials by surface engineering techniques. Thermally sprayed tungsten carbide-based coatings are often feasible approaches to improve the wear resistance of a metallic surface. Therefore, these coatings on the components enhance the useful lifespan. The investigation focuses on the wear characteristics in terms of coefficient of friction and wear rate for tungsten carbide coatings. The focus of the chapter is on abrasive wear and erosion since these two types of wear have the maximum contribution to the failure rate in real-life problems. The applications, benefits, and detriments of the coating deposition techniques are summarised.

INTRODUCTION

Over the years, improvement in the efficiency and durability of machinery leads to an increase in the operating temperature of the system. The systems were exposed to hostile operating conditions. This necessitates the development and extensive research on new materials having compatibility with high-temperature applications and can sustain under aggressive working environments (Tyagi et al., 2019). Surface coatings are the best feasible solution to enhance the useful life at a variety of extreme operating

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conditions. They have added advantages of upgrading the surface properties such as hardness, wear, oxidation, and corrosion resistance (Huang et al., 2019). Over the past few decades, extensive research on coatings has been conducted by many researchers and scientists. Consequently, today number of technologies has been developed to deposit a coating on a substrate with cost-effectiveness (Vardelle et al., 2016). The coating acts as a barrier between the substrate material and the working environment of the component. Coating design includes a functional requirement of the surface to ensure a certain level of performance based on failure analysis and mechanism (Ozgurluk et al., 2018; X. Wang et al., 2015; Yuan et al., 2015). The selection of appropriate material is essential to enhance the performance of components and protect them against severe operating conditions.

Tungsten carbide-based are commonly used in numerous applications since they offer excellent wear, erosion, and corrosion (Meekhanthong & Wirojanupatump, 2014; Usmani et al., 1997). The transition metal carbides provide improved mechanical and physical properties such as high hardness and fracture toughness, excellent wear resistance, high melting point, good thermal stability and chemical inertness (Djafer et al., 2014; Jhi et al., 1999). Therefore, transition metal carbides coatings are used as wear-resistant and corrosion-resistant coatings (D. D. Kumar et al., 2017). The plasma spray (PS) and high-velocity oxy-fuel (HVOF) are favourable techniques among the thermal spray variants for the deposition of tungsten carbide-based coatings (Dorfman & Sharma, 2013; Zhe Geng et al., 2016; Hardwicke & Lau, 2013; V. Kumar & Balasubramanian, 2016; Vardelle et al., 2016) . The WC-based coatings are possible to deposit successfully on a wide range of substrate material using APS and HVOF techniques which are essential to extend application areas (Bolelli, Hulka, et al., 2014). The basic difference in the working principle of APS and HVOF techniques is related to the utilisation of kinetic and thermal energy. The plasma spray uses higher thermal energy and lower kinetic energy during the deposition of the coating. Moreover, HVOF techniques are based on higher kinetic energy with comparatively lower thermal energy. The WC-based coating compositions such as WC-Co (Hazra et al., 2012), WC-NiCr (Liu et al., 2008), WC (Zheng, 2013), WC-CoCr (Murthy & Venkataraman, 2006), WC-Cr_3C_2-Ni (Bhosale et al., 2019; Bolelli, Berger, et al., 2014; Ishikawa et al., 2007) has been deposited using thermal spray variants to improve the wear resistance of the substrate in numerous applications.

The study of the effect of degree of oxidation on the tribo-behaviour of coatings is one of the challenging tasks since argumentative results were reported by researchers. The change in the hardness and fracture toughness of phases in the coating with an increase in the temperature is noticeable, which added with hardness and fracture toughness of newly developed oxide phases and creates further complexities to predict the wear (Balamurugan et al., 2012; Federici et al., 2017; Mi et al., 2018; Myalska et al., 2019; Xie et al., 2013). The dry sliding behaviour of WC-based coatings in the inert gas environment at elevated temperature provides details about the contribution of the tribo-oxidation process in the wear mechanisms of the coating. The self-lubricated WC-based composite coatings developed by the researchers is helpful to lower the coefficient of friction (Bhosale & Rathod, 2020a).

The failure of components such as gas and steam turbine blades (Ilieva, 2016; Kazempour-Liacy et al., 2011; Laguna-Camacho et al., 2016), superheaters and boiler tubes (Firouzeh et al., 2018; S. Kumar et al., 2018) is due to the impingement of solid particles suspended in the fluid. Consequently, the shut-down of plants resulted in massive economic losses which are unavoidable during maintenance and replacement of the components. The stainless steel and alloys of nickel are most commonly used for these components. Due to inferior high-temperature erosion (Firouzeh et al., 2018; Ilieva, 2016; Kazempour-Liacy et al., 2011), the useful service life of these components is less. The material removal by high-temperature erosion is dependent on the hardness of the erodent and the hardness of the material

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