

Chapter 50

Abrasion–Corrosion of Thermal Spray Coatings

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ABSTRACT

WC-based thermal-spray and High Velocity Oxy-Fuel (HVOF) coatings are extensively used in a wide range of applications ranging from downhole drilling tools to gas turbine engines. WC-based thermal spray coatings offer improved wear resistance as a result of hard phases dispersed in binder-rich regions. However, the presence of hard and soft phases within the coating can also lead to the formation of micro-galvanic couplings in aqueous environments leading to some reduction in combined wear-corrosion resistance. Furthermore, the coating also responds differently to change in mechanical loading conditions. This chapter examines the wear-corrosion performance of thermal spray coatings in a range of wear, electrochemical, and wear-corrosion tests under varying contact conditions to develop models and establish relationships between wear mechanisms, wear rates, and environmental factors such as pH and applied load.

INTRODUCTION

Using ceramic–metallic (cermet) or hard oxide coatings to protect metallic components is an effective method to reduce wear and corrosion. Modern surface engineering research is looking into depositing a wide range of hard phases such as carbides along with corrosion resistant metal binder elements with the aim of achieving good adhesion between carbides and binders and therefore successfully combining corrosion and wear resistant elements together. Generally cermet coatings consist of WC or Cr_3C_2 particles embedded in a metal binder, which can be a pure metal or a mixture consisting of Ni, Cr or Co. Hard oxide coatings are typically based on Cr_2O_3 .

The High Velocity Oxy-fuel (HVOF) spray technique is commonly used for depositing wear resistant WC-based coatings and has the advantage of generating higher particle velocities and the relatively

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low temperatures involved which minimise degradation of both the coating and substrate (Sudaprasert, Shipway, & McCartney, 2003).

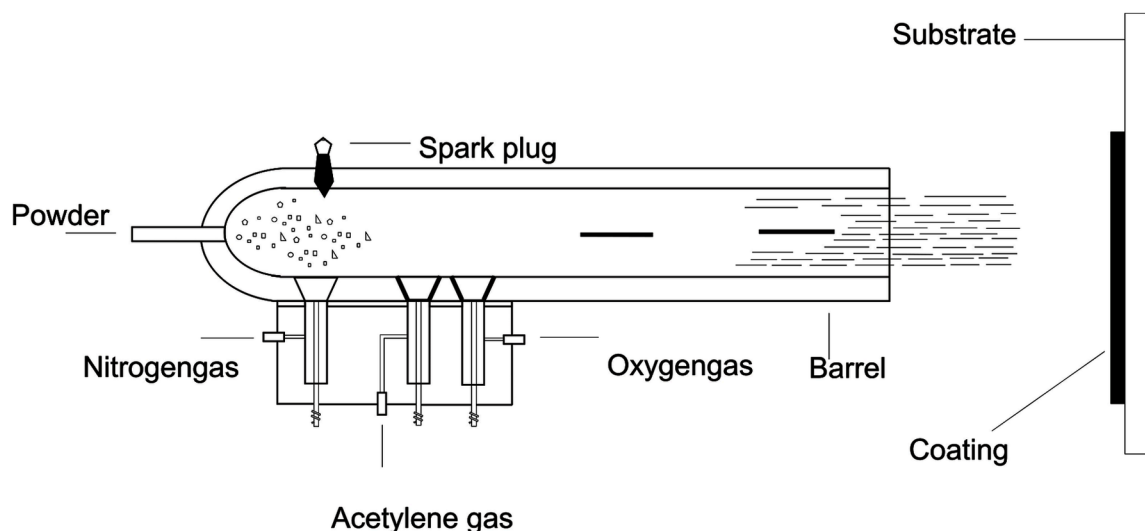
The Detonation gun (D-gun) process shown schematically in Figure 1 is a modification of the conventional HVOF process in which the coating is deposited by means of a detonation caused in the detonation-gun barrel. The advantage of the D-gun process is that it produces a dense coating with minimum porosity (less than 1%) and high adhesion with the substrate (Wood, Mellor, & Binfield, 1997). A mixture of oxygen and acetylene, along with a pulse of pulverised WC, Co and Cr (in correct proportion) are introduced into a barrel and detonated using a spark. The resulting high temperature, high-pressure detonation wave heats the powder particles to around 3000 °C and accelerates them at a velocity of about 750 m s⁻¹ towards the substrate while maintaining relatively low substrate temperatures between 95-150 °C (Tucker, 1999). Although the mechanism of bonding of the particles to the substrate is not fully understood, it is thought to be largely due to mechanical interlocking of the solidifying and shrinking “splats” (lamellar structure) with the asperities on the surface being coated (Tucker, 1999). These splats are approximately 50 µm wide and 10 µm thick and can vary depending on factors like velocity of deposition and the rate of cooling.

Coating Microstructure

The HVOF WC coating microstructure is extremely complex and consists of WC grains in an amorphous matrix consisting of Co with W and C in solution, see Figure 2. Compared to the uniform distribution of carbides and binder observed in sintered hardmetals, the coating shows a random distribution of carbides and binder rich areas referred to as cobalt-lakes.

During the spraying process, the WC particles partially melt and react with the binder to form metallic W and complex WC-M (where, M is the binder) compounds (Verdon, Karimi, & Martin, 1998; Wood et al., 1997).

Figure 1. Schematic of the detonation gun process (Praxair Surface Technologies Ltd.)



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