Chapter 2
Principles and Applications of Thermal Spray Coatings

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ABSTRACT

The goal of the chapter is to address the fundamental theory of thermal spraying and its modern industrial applications, in particular, those involving flame spray, HVOF, plasma spray, and cold spray processes. During the last 30 years, thousands of manuscripts and various book chapters have been published in the field of thermal spray, displaying the evolution of thermally sprayed coatings in many industrial applications. Thermal spray coatings are currently interesting for different modern applications including prosthesis, thermal barriers, electrochemical catalysis, electrochemical energy conversion devices, biofouling, and self-repairing surfaces. The chapter will explain the fundamental principles of the aforementioned thermal spraying processes and discuss the effect of different controlling parameters on the final properties of the produced coatings. This chapter will also explore current and future industrial applications of thermal spray coatings.

LIST OF COMMON ABBREVIATIONS

APS: Atmospheric Plasma Spray
ASI: Adiabatic Shear Instabilities
CAPS: Controlled Atmosphere Plasma Spray

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CGS: Cold Gas Spray
dB: Decibels (dBA is noise power measured in dB)
DC: Direct Current
D-Gun: Detonation Spray
HPCS: High Pressure Cold Gas Spray
HV: Hardness Vickers
HVAF: High Velocity Air Fuel
HVOLF: High Velocity Oxygen Liquid Fuel
HVOF: High Velocity Oxygen Fuel
HRC: Hardness Rockwell C
HVSFS: High Velocity Suspension Flame Spray
LPCS: Low Pressure Cold Gas Spray
LPPS: Low Pressure Plasma Spray
PS-PVD: Plasma Spray Physical Vapor Deposition
SPS: Shrouded Plasma Spray
TS: Thermal Spray
TWA: Twin Wire Arc
VPS: Vacuum Plasma Spray

INTRODUCTION TO THERMAL SPRAY

General Background

Surface modification of materials is a topic that has been intensively studied for the last hundred years to improve, transform, or provide specific functions to a surface originally designed to perform a definite task. Different methods have been employed to modify the surface of materials; for instance, the deleterious effects of corrosion on steels are controlled by applying a layer of a reactive and low melting point metal such as Zn (Marder et al., 2000). A similar protective effect is produced on the surface of iron-based materials when a polymer is deposited on their surface (Ates et al., 2016); however, the pursued application and the specific surface requirements dictate the procedure and more suitable materials for protecting or modifying the surface. Large numbers of materials and processes have been developed for providing surface modification to different substrate materials, from polymers, metals, and ceramics, to electronics, composites, biomaterials, and a myriad of possible combinations in the middle. Thermal spraying (TS) occupies a very specific niche among the technologies developed for providing specific surface features to metallic, ceramic, and composite materials. TS encompasses a group of coating technologies employed for applying metallic and nonmetallic materials on different types of substrates in order to provide them with specific features such as elevated corrosion resistance, biocompatibility, lubrication, high abrasion resistance, electrical and thermal insulation, etc. (Knight et al., 1998). Raw materials employed in such technologies can be in the form of powders, wire, or rods, depending on the selected TS process. All TS processes encompass thermal and kinetic contributions to the overall energy balance between the energy source and the sprayed material (Pawlowski, 2008). Depending on the TS process configuration, thermal and kinetic contributions to that energy balance can be modified; for instance, in high energy processes such as plasma, raw materials receive a larger amount of thermal