Transilvania University of Brașov

HABILITATION THESIS

Advancements in industrial thermal spraying: process optimization, coating development, and novel applications

Domain: Industrial engineering

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The habilitation thesis, "Progress in industrial thermal spraying: process optimization, coating development, and innovative applications," presents original research conducted by me following the conferral of a PhD in Industrial engineering in 2009. The research focuses on optimizing technological parameters for flame and powder spraying processes, resulting in superior-performance coatings with broad applicability in various fields, including industrial engineering, surface engineering, and electrochemistry.

The multidisciplinary research results, presented in section B2 of the habilitation thesis, are structured into four chapters: 1. Thermal spraying technologies in industrial engineering; 2. Critical process parameters in flame spraying of powders: Influence, optimization, and impact on coating quality; and 3. Experimental development and characterization of advanced thermal spray coatings. The habilitation thesis also concludes with elements related to career development and academic evolution plans (section B3).

The first chapter provides a detailed analysis of the evolution of thermal spraying technologies, focusing on methods for achieving high-performance coatings in surface engineering. The presentation identifies and discusses key technical challenges, including oxidation control, maintaining material phase stability, and optimizing production process efficiency. These aspects are crucial for obtaining durable and high-quality coatings.

Chapter two details the technological parameters of the flame spraying process and their impact on achieving coatings with superior mechanical, physical, and chemical properties. A thorough analysis of these parameters, and the ability to strategically modify them, is illustrated through a series of experimental studies conducted by me and presented in detail in Chapter three. These studies form the foundation for improving thermal spraying technology and developing optimized coatings that meet the stringent requirements of industrial applications.

Chapter three, based on my research, demonstrates that using electrically charged powders improves the physical and mechanical properties of deposited layers. This leads to enhanced homogeneity, microstructural hardness, and superior adhesion. Conversely, samples without electrically charged powders exhibit a non-uniform structure and a lower quality interface.

This chapter also explores the influence of using an argon (Ar) protective gas to reduce oxidation during the deposition process. This significantly lowers the electrical resistivity of the deposited layer. This improved electrical conductivity optimizes the material's performance in applications requiring conductive layers with low resistance. The importance of precise argon atmosphere control is highlighted, as it maintains material integrity and enhances functionality.

Two applications of solar thermal treatments are also presented, demonstrating improvements in homogeneity and substrate interface for copper – aluminum – iron and copper – nickel powders deposited by thermal spraying. The thermal treatment process fostered the formation of intermetallic compounds, leading to increased hardness and wear resistance.

Another application of thermally sprayed coatings lies in photocatalysis, where their ability to enhance water and air purification processes is exploited. Applying metallic or composite metallic layers to substrates creates an efficient charge transfer interface, reducing electron-hole recombination and thus increasing photocatalytic activity. These coatings also provide mechanical and chemical stability, extending the lifespan of photocatalytic systems. Furthermore, thermal spraying modifies the materials' optical properties, increasing light absorption.

The study investigated the influence of laser deposition speed on the properties of the deposited coatings. Higher deposition speeds (90 mm/s) resulted in improved hardness due to reduced dilution. However, this speed also raised concerns regarding occupational exposure to metal emissions during the process.

The academic career development plan, both in teaching and research, is detailed in section B3 of the habilitation thesis. Future research directions include:

- **Optimization of flame spraying parameters for NiCrAlX-based powders:** Focusing on achieving corrosion-resistant coatings.
- **Optimization of flame spraying parameters for biocompatible powders:** Investigating biocompatible powders such as zirconium dioxide, aluminum oxide, and calcium oxide.
- **Laser fusion of flame-sprayed coatings:** Exploring the use of laser beams to further enhance the properties of coatings deposited via the flame spraying process.
- **Expanding applications of protective gas-environment coatings:** Aiming to reduce the weight of components while maintaining performance.

My research output to date comprises **50** articles with impact factor (indexed by Clarivate Analytics Web of Science) and **12** articles in ISI proceedings. I have also served as principal investigator on four research grants, demonstrating my ability to secure funding and manage projects. My research visibility is further evidenced by a Hirsch index of 12 according to Clarivate and Scopus.