Thermally Sprayed Coatings - Recent Developments

P.P. Bandyopadhyay
Professor
Department of Mechanical Engineering
Indian Institute of Technology Kharagpur

Brief Biographical Sketch

Dr. P.P. Bandyopadhyay graduated in 1989 from Jadavpur University Kolkata. He worked for both his M Tech and PhD degrees at IIT Kharagpur. He worked on grinding during his M Tech thesis work and his PhD thesis was on plasma sprayed oxide ceramic coatings. He served as a postdoc in the Swiss Federal Laboratories for Material Testing and Research (EMPA) and during this period he worked on vacuum plasma sprayed quasicrystals. He has graduated 13 PhD students and mentored three postdocs. He acted a PI to a number of sponsored projects. At present he is a Professor in the Department of Mechanical Engineering, IIT Kharagpur. He leads a thermal spray laboratory and his present team comprises of seven PhD students and two postdocs. He has published around 150 papers in reputed peer reviewed journals and conference proceedings. His current research interests include carbide coatings, reinforced thermally sprayed coatings, self lubricated coatings and coatings for water purification.

Abstract

Thermal spray processes--such as plasma spraying, high-velocity oxy-fuel (HVOF) spraying, and similar techniques--are widely employed to deposit a broad range of materials, including ceramics, metals, cermet, polymers, and composite materials. These coatings are primarily used to enhance resistance to wear (tribological applications), provide thermal protection at elevated temperatures (thermal barrier coatings), and improve corrosion resistance. Additionally, they find applications in areas related to optical and gas-sensing functionalities. Two key aspects of thermal spraying are deposition parameters and feedstock materials. In any thermal spray process, numerous operational parameters are involved. For instance, in air plasma spraying, parameters include primary and secondary gas flow rates, primary and secondary gas pressures, electric current, stand-off distance, and several others. Despite the large number of controllable parameters, their combined effect ultimately results in two measurable in-flight particle characteristics: particle temperature and particle velocity. These two parameters play a decisive role in determining the microstructure, properties, and overall performance of the deposited coatings. Consequently, focusing on particle temperature and velocity rather than individual spray parameters significantly simplifies process analysis and control. The second major research direction involves modifications of feedstock materials. Incorporation of various reinforcements, such as multi-walled carbon nanotubes (MWCNTs), has been shown to substantially enhance the properties and performance of a widely used cermet like WC-Co. However, the retention of such dopants during spraying often presents a significant challenge owing to their relatively low boiling points, e.g., fluoride-based solid lubricants (e.g., CaF_2 or BaF_2). To address this issue, the application of thin metallic coating layers has been found to improve their retention during deposition. Furthermore, the use of ternary oxide solid lubricants has demonstrated considerable potential for enhancing the tribological performance of such coatings. Thus, this talk purports to address certain key aspects of recent developments in thermally sprayed coatings.