Title:

Implementation of Artificial Intelligence in Thermal Spraying

Subject:

Surface treatment includes a series of technologies that can modify the mechanical, physical and chemical properties of substrate by artificially forming a layer of materials. It is able to meet the corrosion resistance, wear resistance, decoration or other functional requirements of the product. For example, methods like Chemical vapor deposition (CVD) or physical vapor deposition (PVD) can provide surfaces with hardness or corrosion resistance by offering thin films with thicknesses of less than 20 µm. However, the terms like the deposition rate, coating thickness and costs have limited the further applications. Thermal spray (TS) is a material deposition process, where melted or solid feedstock powders are deposited on the surface of a substrate, to provide various protections and additional functions. Based on specific technique principle and feedstock material, thermal spray is able to deposit a coating with thickness ranging from several µm to mm. In this process, the feedstocks are accelerated in a fluid stream through a spray nozzle or torch by high-energy source such as plasma, flame and high-pressure gas. With the consolidation upon impact on substrate, the coating can be formed through successive layers. With its abilities to provide corrosion protection, wear control, damage repair, fouling protection and temperature/oxidation protection, thermal spray has drawn more and more attentions in manufacturing industry.

From late 1980s, the thermal spray technology that was originally developed by academic research in laboratory, was gradually accepted by industrial-scaled production owing to the improvement in process stability, scientific understanding and coating quality. However, the application is still limited from the high-added value components in the field like aeronautic and nuclear industries. Nowadays, thermal spray technology has been more and more applied in various industrial production. In such spray fabrications for industrial application, the primary importance is to maintain the coating quality as well as the reproducibility of the coating characteristics. As a technique originating from laboratory, a significant difference of plasma spraying technology cannot be avoided while transplanting to industry production. The latter are mainly concerned with coating service properties (wear and corrosion resistance, thermal protection, etc.) and coating repeatability, reproducibility and reliability, while researchers in laboratories seek to understand the coating process and the resulting coating microstructure and properties. In recent years, much progress has been made at the scientific understanding of TS process as well as diagnostic equipment, which has enabled detect and discover the process-structure-property relations during the fabrication. However, issues related to TS process and coating reliability continue to confound academic and industrial researchers.

Generally, the conventional spray method to obtained desired coating quality is mainly achieved by an iterative procedure, which is through the parameter determination, spraying experiment and evaluation of coating quality. These steps will be repeated till a desired experimental result is obtained. Thus, a well control of coating properties with high reproducibility and wide variability with predictable performance and life can reduce the rework cost, increase its service life and performance, decrease cost for warrantee and re-production due to failed coating. To maintain the reliability and reproducibility of TS production, it is of great importance to control and modify the operating

parameters according to the in-situ deposition features, such as particle in-flight temperature and velocity, coating temperature and thickness, etc.

As stated above, there are urgent needs from industry and academy for the development of advanced intelligent thermal spray system. To increase the reliability and reproducibility of thermal spray production in industrial applications, this thesis will focus on a novel intelligent thermal spray system, which is capable of providing online controlling and modification of spraying parameters based on in-situ monitoring. The main objective of the thesis is to develop a cyber-physical thermal spray system that utilizes artificial neural networks to learn the coating deposition model by processing the received data and to optimize the spray process.

Related references:

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Keywords:

thermal spray, coating, automation, numerical modeling, robot kinematics, artificial intelligence, cyber-physical system

Concerned knowledge:

Automation development experience (IEC 61131-3), Software development experience (C#/C++), CAD/CAM software (CATIA/CREO…), Material science knowledge, FEM basics, Simulation software (COMSOL Multiphysics, ANSYS FLUENT), Group working experiences