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Key words: Cold spray, Erosion, Design of Experiments

Extended abstract

Solid Particle Erosion (SPE) occurs when solid particles dragged by fluid means impinge on the surface of pneumatic or hydraulic systems resulting in loss of their mass. Multiple potential solutions to the problem have been investigated, including the modification of the machinery design and the use of filtration systems. From the perspective of materials engineering, the alleviation of SPE in metals has been widely encountered with the fabrication of coatings [1], using methods such as laser cladding, plasma spray, high-velocity oxyfuel and cold spray (CS) [2]. CS is a low-temperature particle deposition process in which microscale powder particles are accelerated to a high velocity (300 to 1200 m/s) through a De-Laval nozzle dragged by a high-pressure propelling gas (commonly nitrogen or helium) toward a target substrate [3]. The advantages of this powerful technique over other thermal spray processes include minimizing potential phase changes, preserving the original feedstock properties, and preventing coating defects, such as surface oxides and other inclusions.

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Amongst nickel-based superalloys, Inconel 718 (IN718) is commonly used in applications where stability at elevated temperatures, high long-time creep strength, and corrosion resistance in aggressive environments are required [3].

The complex nature of the SPE mechanism involves several variables related to the erodent properties (e.g., feed rate, velocity, size, hardness, impingement angle) and variables related to the intrinsic properties of the coating materials. As a result, identifying a standard method for predicting the erosion performance of coatings is extremely difficult. To this end, one of the most widely adopted techniques to assess the effect of control variables on coating erosion resistance is the Design of Experiments (DoE) [4], [5]. To date, few empirical studies have investigated the erosion performance of cold spray coatings through experimental design [6], which is a major innovative aspect of this study.

The authors adopted a general full factorial design to investigate the SPE resistance of cold sprayed IN718-Ni composite coatings. The coatings were deposited onto substrates via high-pressure CS using nitrogen as the propulsive gas, with inlet pressure at 3.0 MPa and gas temperature at 1000 °C. The effect of the impingement angle (°), the erodent size (μm) and the erodent feed rate (g/min) on the erosion rate (mg/min) of the coating was investigated.

Empirical results showed that the erodent feed rate and the impingement angle produced a statistically significant effect on the erosion rate, as well as the interaction between erodent size and impingement angle. Furthermore, a mathematical model relating such variables with the erosion rate was identified by stepwise regression analysis. This model effectively allows predicting the erosion performance of real components deposited with IN718-Ni coating under working conditions and properly designing the in-service conditions of new cold-sprayed components. The set of parameters optimizing the erosion rate was accordingly derived by performing an optimization, and then validated. Finally, the worn surfaces of the coatings were observed by SEM in order to understand the erosion mechanism.

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