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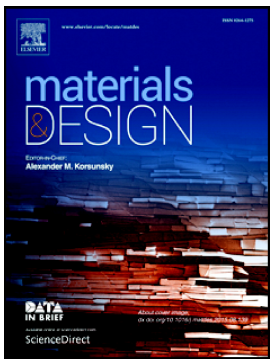

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On the Evolution of Substrate's Residual Stress during Cold Spray Process: A Parametric Study

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Abstract

A comprehensive study was undertaken to determine the effects of carrier gas temperature, pressure, and nozzle speed on the residual stresses induced by cold spray coating of aluminum 7075 powder onto AZ31B-H24 magnesium substrate. Embedded Fiber Bragg Grating sensors and thermocouples were employed for simultaneous in-situ measurements of strain and temperature during cold spray process. A statistical model was then developed based on the significance and interactions of the cold spray parameters on the residual stress field. This model demonstrated that the induced temperature is the most significant parameter to the final formation of residual stress. It is also shown that the peening effect plus the temperature resulted from the cold spray yields to the dynamic recrystallization of the substrate near the surface, and generates nano-size grains at the interface. This research validates that the final size of the refined grains and the level of induced residual stress depend heavily on the process' thermal energy.

Keywords: Cold spray; Magnesium alloys; Aluminum powder; Residual stress; Grain refinement; Fatigue failure

1. Introduction

Developing effective approaches to extending the life of aging structural materials is a major challenge, particularly for load-bearing components. Since majority of structural failure is attributable to fatigue, research focused on the enhancement of fatigue strength in structural materials has become significant [1]. For this purpose, inducing beneficial residual stresses at critical locations, where fatigue cracks nucleate, is shown to be a successful approach to postponing the fatigue crack failure of mechanical components during service [2, 3]. Moreover, strengthening the material surface with the coating of high fatigue resistance material is a technique for increasing the life of a low fatigue strength material [4]. "Cold Gas Dynamic Spray" technology, a solid state coating process, creates both mentioned benefits [5]. This coating method can be used to deposit micron-sized metal particles that have been accelerated to a high velocity (300-1200 m/sec) onto a material's surface via a de Laval nozzle [6]. The particles and substrate are severely deformed upon impact, resulting in mechanical/metallurgical bonding between the substrate and coating because of

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