Finite Element Modeling of Mechanical Properties of 3D Printed 718 Nickel-Based Superalloy with CrN Coating

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Abstract
In this work, a finite element model is implemented to simulate the indentation of PEMS (Plasma Enhanced Magnetron Sputtering) processed CrN coating on 3D printed 718 nickel-based superalloy. The hardness and Young's modulus of the coated sample are calculated as 10.4 GPa and 264.83 GPa, respectively through FE simulation. The modeling results show that the calculated mechanical properties are in good agreement with the experimental data. The results of this study could contribute to the design and improvement of the process.

Keywords: Finite element model, PEMS (Plasma Enhanced Magnetron Sputtering), 3D printing, 718 nickel, CrN, Mechanical properties

1. Introduction

Superalloy 718 is a widely used material in the aerospace industry due to its excellent properties such as good mechanical properties, high temperature oxidation resistance, and low-temperature stability. However, the traditional forming method for this alloy is limited, and 3D printing technology has shown promise in solving the problem of manufacturing complex-shaped parts [1-4]. The surface modification of Superalloy 718 can effectively improve its comprehensive performance and extend its service life under extreme environments[5]. Different surface modification techniques have been used to modify the surface properties of this alloy, and some studies have investigated the effects of surface modification techniques on the properties of this material[6-8]. However, the potential of PEMS treatment as a surface modification technique for 3D printed 718 alloy has not been fully explored to figure out the ultimate effect on the material's mechanical property.

To obtain material properties, the nanoindentation test provides a dependable approach for measuring the mechanical properties of materials and is an alternative to conventional mechanical test methods. This method requires a smaller amount of sample material, reduces expenses, and is not influenced by the shape or dimensions of the specimen [9-11]. Finite element analysis (FEA)