Influence of additive manufacturing process parameters on cemented carbides : microstructural and mechanical behavior with Weibull analysis of sintered parts

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Abstract

Cemented carbides, primarily composed of tungsten carbide and cobalt, are traditionally manufactured through powder metallurgy processes that require full densification. However, in response to the growing demand for more sustainable manufacturing methods, additive manufacturing (AM), particularly Metal Binder Jetting (MBJ), is emerging as a promising alternative. Despite its potential, significant challenges remain in understanding the relationship between AM process parameters, powder physico-chemical properties, microstructure evolution, and the mechanical performance of sintered parts.
In this study, we address two key aspects of cemented carbide manufacturing via MBJ. First, we investigate the effect of printing parameters on green parts, highlighting how defects induced during the printing process affect the quality and mechanical properties of the non-sintered parts. Specifically, we focus on the impact of printing parameters on properties such as relative density and porosity.

Second, we apply Weibull statistical analysis to evaluate the mechanical reliability of sintered parts. This analysis quantifies the variability in the mechanical performance of sintered parts, accounting for residual defects introduced by the printing process. We also explore the relationship between microstructural characteristics, such as grain size and homogeneity, and

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the mechanical properties of sintered parts, considering both commercially available powders and in-house produced powders.

A series of mechanical tests, including 3-point bending, 4-point bending, and biaxial flexure, are conducted to assess mechanical performance under various loading conditions. Hardness, fracture toughness, and bending tests are complemented by microstructural observations using SEM and EDS techniques, providing a comprehensive analysis of the material's properties.
The findings highlight the importance of printing parameters in determining the mechanical behavior of green parts and demonstrate, through Weibull analysis, how these parameters influence the reliability of sintered parts. This study contributes to a deeper understanding of the relationship between manufacturing processes, microstructure, and mechanical performance in additive-manufactured cemented carbides.