Comparative Study of Gas and Water Atomized AISI 4340 in Laser Powder Bed Fusion

Allan David Rogalsky [1], Justin Memar-Makhsous [1], Yunyi Jiang, Issa Rishmawi [1], Amin Molavi-Kakhki 2, Mihaela Vlasea [1]
[1] University of Waterloo, Waterloo, Ontario, Canada
[2] Rio Tinto Fer et Titane, Sorel-Tracy, Québec, Canada

ABSTRACT

A limited body of literature has investigated the adoption of water atomized (WA) powder in laser powder bed fusion (LPBF) additive manufacturing (AM) with respect to part density. This work studies the impact of two powder production methods, WA and gas atomization (GA), on part characteristics for the AISI 4340 alloy. To achieve this comparison, a simulation-driven approach was used to select a wide range of parameters spanning the general LPBF process window expected to give good results for AISI 4340. Artifacts were printed using identical LPBF machine settings for both GA and WA powder and were evaluated for part bulk density, top surface roughness and a side surface roughness. These are discussed in relation to powder properties namely: powder size distribution (PSD), particle morphology, tap density, dynamic angle of repose, cohesive index, and laser absorptivity. Performance overall was similar for both types of powders; however, as attributed to a significant difference in apparent laser absorptivity, the maximum achieved density for WA powder was only 99.5% compared to the 99.98% achieved with GA powder. Future performance improvements when using WA powder feed stock in LPBF are expected when this difference is accounted for.

INTRODUCTION

Additive manufacturing (AM) is revolutionizing the global economy across multiple sectors, with an increased presence across various aspects of product innovation and supply chains [1]. Recent reports such as the 2020 BCC Research Report on “Global Markets for 3D Printing” [2] corroborate this statement, with a global market of $10.2 billion in 2019, and a forecast of $27.5 billion by 2024, with a compound annual growth of 22% between 2019-2024. Metal AM technologies such as laser powder bed fusion (LPBF) are highlighted as having a high importance in the manufacturing sector. AM technologies can theoretically enable the creation of