# AM Using Novel A8 Tool Steel Powders Produced by Water Atomization

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***Abstract:***

Most additive manufacturing processes use gas-atomized metal powders as their raw material. The development of metal powders for AM produced by water atomization could bring significant advantages related to the powder production rate and therefore, to the reduction of costs for alloys that can be produced by this technique. Given recent developments allowing the production of regular (almost spherical) particles by water atomization, the fabrication of tool steel powders by this approach is worth exploring. It can be shown that water atomization of ferrous alloys can be adapted to produce powders with similar and even better rheological properties than gas atomized powders. Additionally, unique strategies can be developed to increase the volume fraction and size of carbides present in final parts by adding them to the powder by pre-mixing or pre-alloying. This study is concerned with the improvement of the properties of parts made from A8 tool steel powders produced by water atomization. These powders have been modified in terms of chemical composition and by the addition of WC particles. Plasma spheroidization of as atomized powders and premixes was also performed to measure its effect on the rheological properties of the powders as well as the mechanical properties of parts manufactured by Laser Powder Bed Fusion.

## 1. Introduction

Metal additive manufacturing (AM) processes mainly use powders produced by gas atomization. The latter process yields spherical particles with low oxygen content. These characteristics are particularly important for AM as they maximise the rheological properties of metals powders and reduce the volume fraction of oxide inclusions in printed components. Nevertheless, gas atomization does come with disadvantages that are mainly related to its higher production costs and the frequent presence residual pores within individual particles due to gas entrapment.

Water atomization produces metal powders at much lower cost than gas atomization. Nevertheless, the particles obtained from water atomization are typically irregular in shape towing to the significantly higher cooling rate through the use of water as the atomizing fluid. Additionally, water atomized metal powders are often characterized by the presence of a significant volume fraction of surface oxides due to the reaction between liquid metal and water vapor.

Several strategies can be utilized to improve the sphericity of water atomized particles. Firstly, the water atomization process itself can be modified to optimize yield for a given particle size distribution (PSD), and/or to promote more regular particles with lower oxygen content [1]. Secondary operations such as milling may also be explored to spheroidize irregular particles. As for the elimination of residual oxides, hydrogen annealing is well known for its efficiency in this regard. Oxidation can also be limited during water atomization by modifying/optimizing the chemical composition of certain alloys. Indeed, it has been proven that oxygen content can be significantly lowered in water atomized stainless steels by controlling the ratios of certain elements such as silicon and manganese [2]. The fabrication of toolings used in the metal shaping industry is particularly well suited for additive manufacturing since it requires complex components integrating, among other things, conformal cooling channels. The development of such tools allows