Comparison of Simulated and Experimental Observations of Pure Ni Gas Atomization: Surrogate for Development of Parameters to Produce Ni-base Superalloy Feedstock Powders for AM

Trevor Riedemann[1], Franz Hernandez Gaitan[1], Xxxx Xxxx, & Iver Anderson[1,2]

1. *Ames Laboratory, U.S. Department of Energy, Ames, Iowa 50011*

2. Department of Materials Science and Engineering, Iowa State University, Ames, Iowa 50011

ABSTRACT

The significant expense to prepare pre-alloyed master alloy and elemental additions can be cost prohibitive for university or national lab research. Pure nickel was used as a surrogate in development of gas atomization parameters for Mar M 247™ type superalloy powder for additive manufacturing (AM). A comparison of the experimental and simulated Ni atomization dynamics are analyzed and quantified to verify the modeling methods. Examination of the impact of physical property differences of pure Ni and the Ni-based superalloy on the predicted and actual measured powder size distribution will be discussed. Work funded by USDOE-EERE-AMO through Ames Lab contract DE-AC02-07CH11358.

1. INTRODUCTION

As part of the US DOE Advanced Manufacturing Office's efforts to spur development and increase deployment of advanced manufacturing techniques, such as additive manufacturing(AM) or 3D printing, the Ames Laboratory endeavored develop a 3D printable modified Mar-M-247™ superalloy[1]. The original alloy was developed for casting methods, and has subsequently been modified for single crystal methods. AM methods are requiring further modification to remove cracking and voids/pores in 3D builds. Results of Ames Laboratory work, with ORNL and UNC, have been reported [2,3]. Pure nickel was used as a surrogate in development of gas atomization parameters for Mar-M-247 for two reasons, to reduce the cost of the experimental atomizations in preliminary parameter development and for comparison with simulations. Pure Ni was used in simulations to simplify the calculation of thermal and hydrodynamic states. Such substitutions have also been used for parameter development to mitigate hazards or waste produces during the development phase, gold as surrogate for uranium alloys, for example [4]. In this manuscript, we are looping back to evaluate the reasonableness of such a substitution for the Mar-M-247 case.

The nominal composition and density of Mar-M-247 (MM247), originally developed by Martin Metals is shown below, in alphabetic order, along with a generic profile in Table 1 [5,6]. There are many variants on MM247, moving forward the discussion uses MM247 as generic "family" of metals with nominal compositions related to the Mar-M-247 superalloy. It is seen in the two MM247 compositions given that the density can vary from alloy to alloy. This is will then also be true of the surface tension and viscosity values, Table 2. provides values for the surface tension and viscosity of Ni and MM247 [7,8,9], also included is Ni – 5.97wt%Al – 9.59wt%Cr alloy which serves as an intermediate composition between pure Ni and MM247, which will be discussed in later sections.