The influence of combined Hot Isostatic Pressing (HIP) and heat treatment on the properties of L-PBF IN718

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1. Introduction

1.1 Powder bed fusion IN718

IN718 is a Ni-base superalloy widely used in the aerospace industry because of its good strength, creep and corrosion properties at elevated temperatures. Components of IN718 produced by casting and forging has been used for many years but today there is also a big interest in using powder bed fusion (PBF) of IN718 to produce components with a higher degree of complexity in net-shape. The microstructure and thus properties of IN718 produced with PBF can often be quite different from material produced by the more conventional manufacturing methods.

IN718 is typically given a heat treatment for homogenization and precipitation of the strengthening phases γ'/γ'' that gives the alloy its properties. This heat treatment commonly exists of a solutionizing step, a rapid cooling and a dual-step ageing. Some different versions of the heat treatment are specified in industry standards such as AMS562, AMS5663, AMS5664 and AMS2774. For IN718 components produced with PBF, a HIP treatment is typically applied before the heat treatment to eliminate the internal defects in the material from the printing process.

1.2 Hot Isostatic Pressing (HIP)

Hot Isostatic Pressing (HIP) has been used for several decades within different industries for a wide variety of applications such as castings, near-net shape powder components, metal injection molding and more [1]. During the recent years HIP has become an important post process for metal additive manufacturing (AM) to secure material performance and quality. The HIP process uses a high isostatic pressure and elevated temperature to densify additively manufactured material by eliminating internal defects such as gas porosity, lack-of-fusion defects, microcracks and residual sintering porosity etc. The elimination of defects in the material means elimination of stress concentrations and crack initiation points which results in improved material properties such as fatigue, creep, ductility and fracture toughness [2-8].

HIP have historically been used only for densification and defect elimination and any modification, and the optimization of a material's microstructure was usually performed after the HIP process in a separate heat treatment step in separate equipment e.g. a vacuum furnace. The main reason that these processes have been performed separately is that the achievable cooling rates in HIP systems have traditionally been relatively low, lower than what many materials require for heat treatment to for example create martensite or a super saturated condition etc. For IN718 the HIP step and solutioning and ageing treatment is traditionally performed as separate treatments in different equipment.

1.3 In-situ heat treatment with HIP

One important development within HIP systems during recent years is the rapid cooling HIP furnace that enables high cooling rates in the HIP unit. The high cooling rates are achieved by a forced convection cooling of the highly pressurized argon gas that is used for HIP. The possibility to perform fast cooling