15-5 PH stainless steel is an important alloy in the aerospace, chemical, and nuclear industries for its high strength and corrosion resistance at high temperature. Thus this material is a good candidate for processing development in the direct metal laser sintering (DMLS) branch of additive manufacturing. The chemistry and microstructure of this alloy processed via DMLS was compared to its conventionally cast counterpart through various heat treatments as part of a characterization effort. The investigation utilized optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-Ray diffractometry (XRD), energy dispersive X-Ray spectroscopy (EDS) and glow discharge atomic emission spectrometry (GDS) techniques. DMLS processed samples contained a layered microstructure in which the prior austenite grain sizes were relatively smaller than the cast and annealed prior austenite grain size. The largest of the quantifiable DMLS prior austenite grains had an ASTM grain size of approximately 11.5-12 (6.7m to 5.6m, respectively) and the cast and annealed prior austenite grain size was approximately 7-7.5 (31.8m to 26.7m, respectively), giving insight to the elevated mechanical properties of the DMLS processed alloy. During investigation, significant amounts of retained austenite phase were found in the DMLS processed samples and quantified by XRD analysis. Causes of this phase included high nitrogen content absorbed during nitrogen gas atomization of the DMLS metal powder and from the DMLS build chamber nitrogen atmosphere. Nitrogen content was quantified by GDS for three samples. DMLS powder produced by nitrogen gas atomization had a nitrogen content of 0.11 wt%. A DMLS processed sample contained 0.08 wt% nitrogen, and a conventionally cast and annealed sample contained only 0.019 wt% nitrogen. In iron based alloys, nitrogen is a significant austenite promoter and reduced the martensite start and finish temperatures, rendering the standard heat treatments for the alloy ineffective in producing full transformation to martensite. Process improvements are proposed along with suggested future research.

Major: Materials Science and Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2012, University of Central Florida

Committee in Charge:
Prof. Yongho Sohn, Chair, Materials Science and Engineering
Prof. Kevin Coffey, Materials Science and Engineering
Prof. Martin Richardson, College of Optics and Photonics

Approved for distribution by Prof. Yongho Sohn, Committee Chair, on June 23, 2014.

The public is welcome to attend.