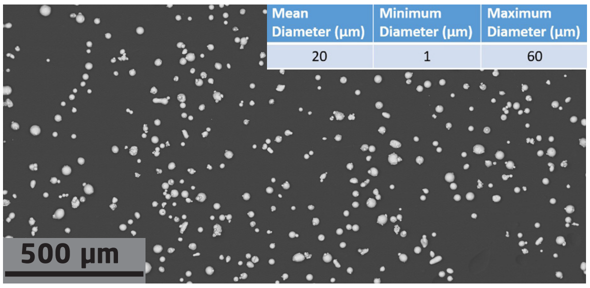
3D Imaging for industrial applications
Additive Manufacturing / Quality Assurance

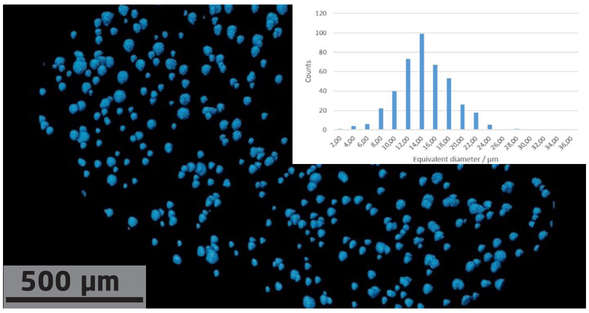
AARHUS UNIVERSITY
FORCE TECHNOLOGY
LINX
Innovation Fund Denmark

Quality Assurance of metal powders used for 3D printing

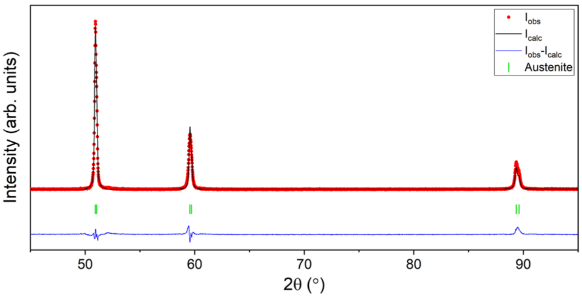
Additive Manufacturing, which is also commonly known as "3D printing", is an emerging technique in industrial production processes. The object is fabricated by the deposition of subsequent layers to create the desired structure. Typically, powder based additive manufacturing techniques are used for metal components, which means that the metal powder particles are placed and either directly fused together, or "glued" before they are fused. If non-fused material remains, it can be re-used. In this project, the company FORCE Technology has engaged with the 3D Imaging Center at DTU and Aarhus University via the LINX project, in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques. Here, the aim is to analyse functional and fundamental properties of virgin and re-used stainless steel powders to determine suitable characterization methods for quality control of such powders.



Scanning Electron Microscopy (SEM) image of virgin steel powder particles dispersed on a carbon tape, and measured particle sizes.



Volumetric 3D representation obtained from X-ray CT of segmented virgin steel powder particles dispersed on a carbon tape and particle size distribution obtained from the measurement.



Powder X-ray diffraction data and corresponding Rietveld refined model of the virgin steel powder showing a pure austenite phase.

General Characterization

At FORCE Technology a variety of different characterization methods for powders were reviewed. In addition to a literature review about standards to be followed in powder-based additive manufacturing, printed samples were analysed with respect to their mechanical properties and their microstructure . Furthermore, light optical microscopy and Scanning Electron Microscopy (SEM) were performed on the powders to obtain particle size distributions. For example, for a 316L stainless steel powder, a mean particle diameter of around 20 µm with a size ranging from 1 µm to 60 µm was found using SEM.

X-ray Computed Tomography

Although SEM provides a high spatial resolution, it offers only limited access to volumetric 3D information. In contrast, X-ray Computed Tomography (CT) provides access to the full 3D structure of the sample, but at limited spatial resolution. At the 3D Imaging Center at DTU, X-ray micro CT was performed using in-house machines. For the 316L stainless steel material, a mean particle diameter of 14 µm and a size ranging from ca. 4 µm to 36 µm was obtained for a measurement performed with 3 µm spatial resolution. Also, the X-ray CT measurements showed mostly spherical particles and supplemented therefore the more precise, but only 2D, SEM measurements.

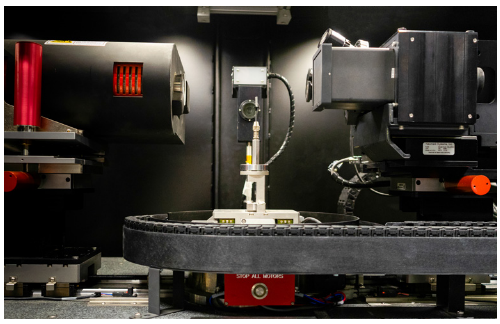
X-ray Diffraction

At Aarhus University, the crystalline phase composition of the virgin and re-used powders, as well as of 3D-printed and conventionally cast test samples, was studied using X-ray diffraction. The diffraction data were collected on an in-house diffractometer equipped with a Co Kα source. The diffraction pattern of the 316L stainless steel powder revealed for example only one crystalline phase (austenite). The same was found for the re-used powder and for the 3D-printed sample. However, the conventionally cast test sample was found to contain a minor martensite phase aside from the major austenite phase. These findings underline the complementarity of the presented methods for material characterization as they support with information about the phase composition of the materials.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Center at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/english/Industry-Portal



DTU 3D Imaging Center