INDUSTRIAL PILOT PROJECT

Utilisation of synchrotron based in-situ XRD and CT to study the effect of the processing gas in laser powder bed fusion

THE INDUSTRIAL CHALLENGE

Recent studies indicate that the use of Helium (He) and its mixtures as processing gas in laser powder bed fusion (LPBF) improve process stability and reduce generation of the process by-products (spatters), which are precursors for defects in LPBF-processed components and powder degradation. Still, the understanding of how He influences the material solidification and the resulting component properties are limited and hinder the development and implementation of gas solutions.

WHY USING A LARGE SCALE FACILITY

Effect of the process gas on the LPBF process stability can be depicted following the kinetics of the phase transformation by X-ray diffraction (XRD) during solidification of the micron-sized melt pool, that is characterised by very high cooling rates (10^4-10^6 K/s). Such analysis could only be performed at synchrotrons, which allows utilising of high flux of the radiation source and ultra-fast detectors, together with the *miniSLM* test rig designed by Paul Scherrer Institute (PSI). The use of synchrotron X-ray computed tomography (SXCT) allows to distinguish porosity distribution in as-printed samples at high resolution as well as measure residual stresses.

HOW THE WORK WAS DONE

The experiments at PSI were conducted at the MicroXAS beamline of the Swiss Light Source synchrotron, using the *MiniSLM* rig designed PSI to enable in situ XRD. The system was used in reflection mode with a 12 keV beam energy. Gases including Ar, He and their mixtures were studied. The SXCT work on LPBF fabricated samples was associated with the Federal Institute for Materials Research and Testing (BAM) and performed at the BAMline at BESSY II synchrotron in Berlin. A monochromatic X-ray beam energy of 45 keV allowed a pixel size of 0.88 µm.

THE RESULTS AND EXPECTED IMPACT

The in-situ XRD measurements performed using the *miniSLM* rig highlighted that utilisation of He allows to reach improved process stability in comparison to the standard Ar as well as slightly higher cooling rates. Decreased spatter generation under He was detected as well, resulting in the improved powder reusability. These results have an important impact on the understanding of the effect of He on the process and further development of the gas solutions at Linde.

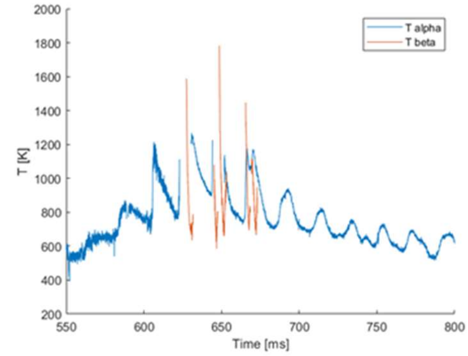

Figure 1. Temperature profile reconstructed from the X-ray diffraction signal collected during printing.

The SXCT measurements showed that application of He does not result in additional residual stresses in the built part and pore distribution and characteristics are comparable between different gases, see Fig.2.

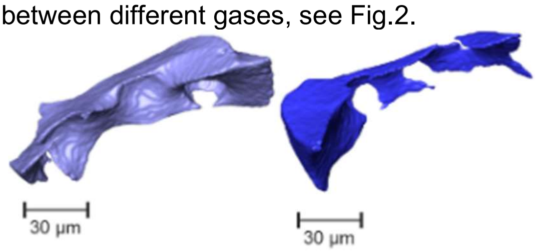

Figure 2. Reconstructed porosity from the SXCT (performed at BAM by T. Mishurova et al.).

In all, the results have permitted Linde to discover current cutting-edge possibilities of monitoring and characterization of both the LPBF process and the produced component at large-scale facilities. In addition, the collaborations led to initiation of several new projects between the PSI, BAM and Chalmers, allowing the Swedish additive manufacturing competence centre CAM² and its industrial partners to strengthen their research activities in that regard.

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Dnr: 2019-05272 **Duration:** February 2020 -- March 2021

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.