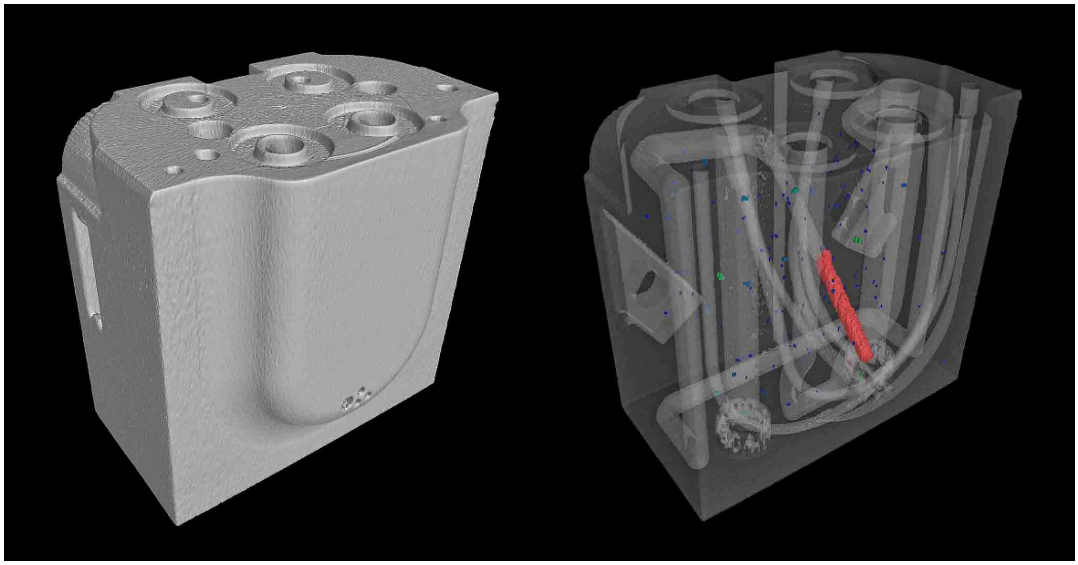
CASE STUDY

X-ray CT services from Nikon support additive manufacturing research



Left: A hot forming die, 35 x 65 x 65 mm.
Right: A Nikon Metrology XT H 450kV X-ray CT system revealed that powder (red) is trapped in a cavity. Voxel size is 56 µm and scan time was 52 minutes.

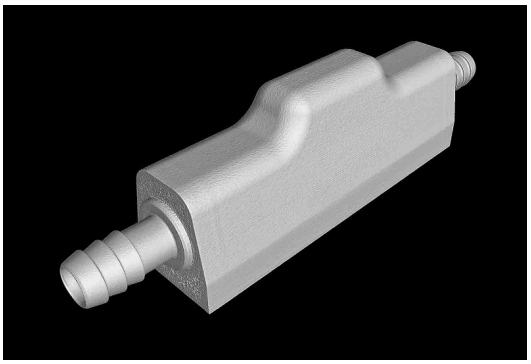
RISE is Sweden's research institute and innovation partner. Through their international collaboration programmes with industry, academia and the public sector, they ensure the competitiveness of the Swedish business community on an international level and contribute to a sustainable society. The 2,800 employees at RISE engage in and support all types of innovation processes. RISE is an independent, State-owned research institute, which offers unique expertise and over 100 testbeds and demonstration environments for future-proof technologies, products and services. Additive manufacturing (AM), also called 3D-printing, is one of many research areas that RISE are active within. The company has focused on binder jetting technology, one of the seven main categories of AM, since the late 90s.

A key provider of X-ray CT (computed tomography) services to Mölndal, Sweden, in support of quality inspection in this area is Nikon Metrology (www.nikonmetrology.com). The Japanese multinational is involved in most areas of inspection, measurement and data recording and analysis for industry and healthcare, offering a wide range of optical instruments harnessing infrared frequencies through the visible spectrum to X-rays.

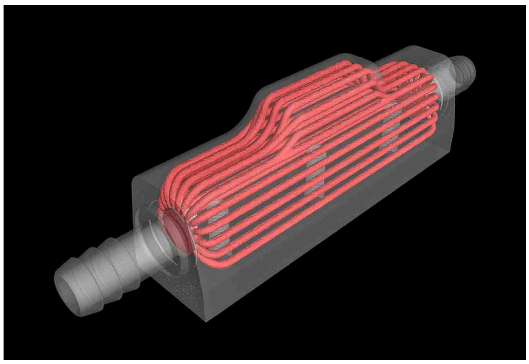
The non-destructive testing (NDT) provided by X-ray CT underpins research into all 3D-printing techniques in use at RISE, mainly laser powder bed fusion (L-PBF), fused deposition modelling (FDM), stereolithography (SLA) and upcoming new 3D-printing technologies. The range of powder materials includes metals, plastics, composites and even sand for casting moulds. Investigations span the entire production chain from idea to finished component, encompassing initial material preparation, design for AM, programming, additive manufacturing and inspection for final verification. These R&D activities help small and large companies to create prototypes in a simpler way prior to manufacturing products of any complexity in quantities ranging from one-offs to series production.

Being a research institute focusing on supporting industry, RISE ensures that the accumulated knowledge gained is disseminated to a wide community not only to boost additive

X-ray CT services from Nikon support additive manufacturing research



An tool steel component measuring 115 x 45 x 35 mm additively manufactured at RISE.



The component was scanned in 50 minutes to reveal its internal structure. Voxel size is 100 µm / 39 µm with PE 1611 helical scanning.

manufacturing, but also to help industry strengthen its competitiveness by using state-of-the-art manufacturing technologies.

Dr Seyed Hosseini, Senior Technical Project Manager and Acting Manager Additive Manufacturing at RISE explained, "As a research organisation working with customers in various industries, including automotive, telecommunications, maritime and energy, it is important for us to have various tools to measure, characterise and evaluate 3D-printed parts.

"NDT by X-ray CT is an especially useful tool when characterising the integrity and dimensional accuracy of specimens under investigation."

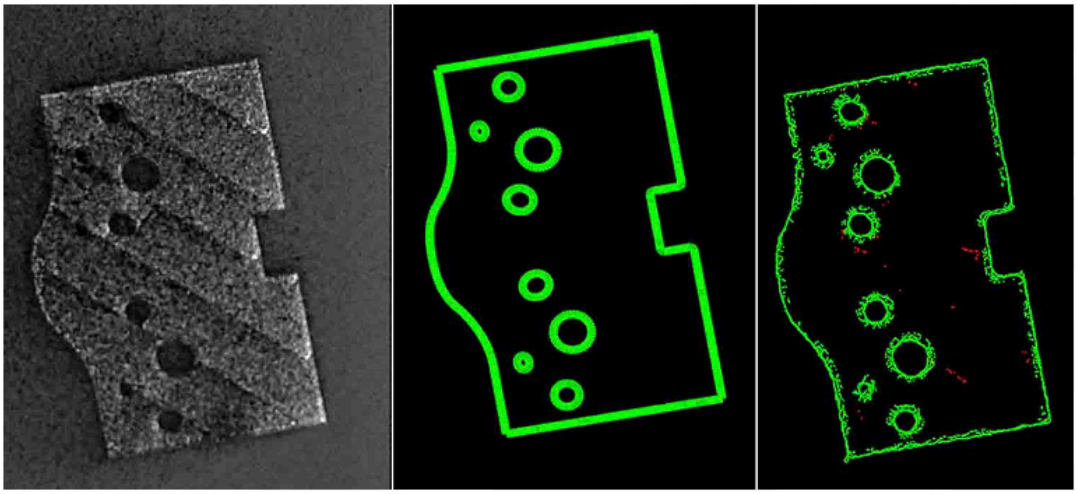
Dr Seyed Hosseini, Senior Technical Project Manager and Acting Manager Additive Manufacturing at RISE

"Characterisation is of prime importance as a way to gain a comprehensive understanding of what can be achieved with the technology. Today, despite all the work that we have carried out to optimise the processes, there is still a lot left to do."

He added that to develop new methodologies that can later be used by industry, his department employs numerous inspection techniques including laser scanning to measure distortion, for example, and optical as well as scanning electron microscopy to detect internal defects such as lack of fusion in a microstructure. One advanced procedure involves in-situ quality assurance during powder bed fusion, whereby a succession of images can be reconstructed to represent the 3D part to reveal distortions that might occur during the printing process.

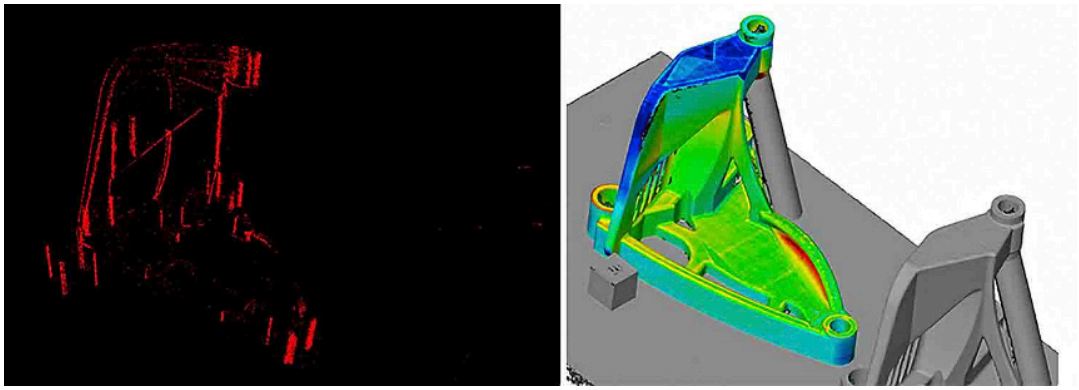
Most inspection techniques are time-consuming to set up, laborious to execute and often require the item to be destroyed by sectioning it. This is why NDT by X-ray CT is an especially useful tool when characterising the integrity and dimensional accuracy of specimens under investigation. This is done on the exterior to optimise topology and internally to detect embedded features, porosity, voids, inclusions and other defects. Data is extracted from each part rapidly and non-destructively with the help of CT services provided externally, either directly by Nikon Metrology or by service bureaux that use its equipment.

Mr Hosseini noted, "It is usually a combination of all these inspection tools that enables us to fulfil the breadth of quality control needed in our



Using RISE software, an original image (left) is compared to its CAD model (centre), resulting in a deviation detection image (right) where pixels in red show potential deviations.

X-ray CT services from Nikon support additive manufacturing research

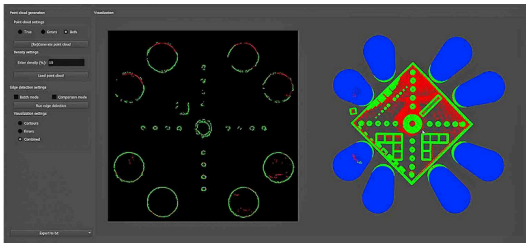


Left: results from the deviation detection software using high resolution images from the 3D printer. Right: the CT scan performed after printing shows similar deviation around the overhang and outside edges.

department. However, without input from X-ray CT NDT, I would say the overall quality of data acquisition would be inadequate.

"With CT, however, we can create good statistics on the location and importance of defects, gain a better understanding of the integrity of a part more quickly, and more accurately optimise the process parameters used in the production of the next prototype iteration.

He added that today Nikon Metrology is involved in several research activities with RISE and other industrial partners, both from Sweden and other countries, which has created a good collaborative platform for increasing the overall knowledge and understanding of AM using state-of-the-art X-ray technology.



At RISE, STL files are compared to images from the 3D printer in real time or after printing. 2D and 3D visualisation of the build process and its defects allows operators to explore the component and quickly find deviations.
Results are saved as point clouds for offline analysis.

"It is important to work with a partner that understands the need for research and development and are supporting our customer projects to jointly increase the knowledge in AM."

Dr Seyed Hosseini, Senior Technical Project Manager and Acting Manager Additive Manufacturing at RISE

Mr Hosseini concluded, "The service has added considerable value to our activities and raised our level of competence in terms of data acquisition, evaluation and correlation with the QC data generated by our internal inspection systems.

"Also, It is important to work with a partner that understands the need for research and development and are supporting our customer projects to jointly increase the knowledge in AM.

"Such interdisciplinary collaboration has the potential to open up many more avenues and intensify our activities, which I think is important not only for all our stakeholders, but also from a scientific perspective."

Responsible for the RISE account within Nikon Metrology is applications engineering manager Lauren Enghien, who is a technical expert in the utilisation of the company's X-ray CT systems as well as Volume Graphics analysis software. He explained that a high power Nikon XT H 450kV microfocus system is employed for inspection of the metal additively-manufactured parts, while a 225kV XT H 225 ST 2x provides information on the internal and external structure of less dense 3D-printed components, such as those made from plastic, aluminium and titanium.

It is noteworthy that the higher power of the 450kV X-ray system, unique on the market, is able to inspect and measure internal features of tool steel samples with very high clarity using spot sizes down to 80 µm at 450 kV. The size of the spot affects voxel size; the smaller it is, the sharper the image. A small spot size is particularly beneficial for dimensional inspection of a part, as sub-voxel accuracy is possible. It is also important for defect analysis, where at least two voxels are needed to detect and measure a void or crack.

The lower power system used is Nikon Metrology's latest machine with Half.Turn CT, which almost halves the angle through which a specimen needs to rotate during the X-ray cycle, speeding the process without loss of image quality. It is possible to use the manufacturer's new generation Rotating. Target 2.0 in both X-ray systems to achieve a threefold reduction in spot size for even clearer imaging. Nikon Metrology's in-house developed Inspect-X software streamlines acquisition and reconstruction of the CT data.

Sales.Europe.NM@nikon.com
www.nikonmetrology.com
+32 16 74 01 00