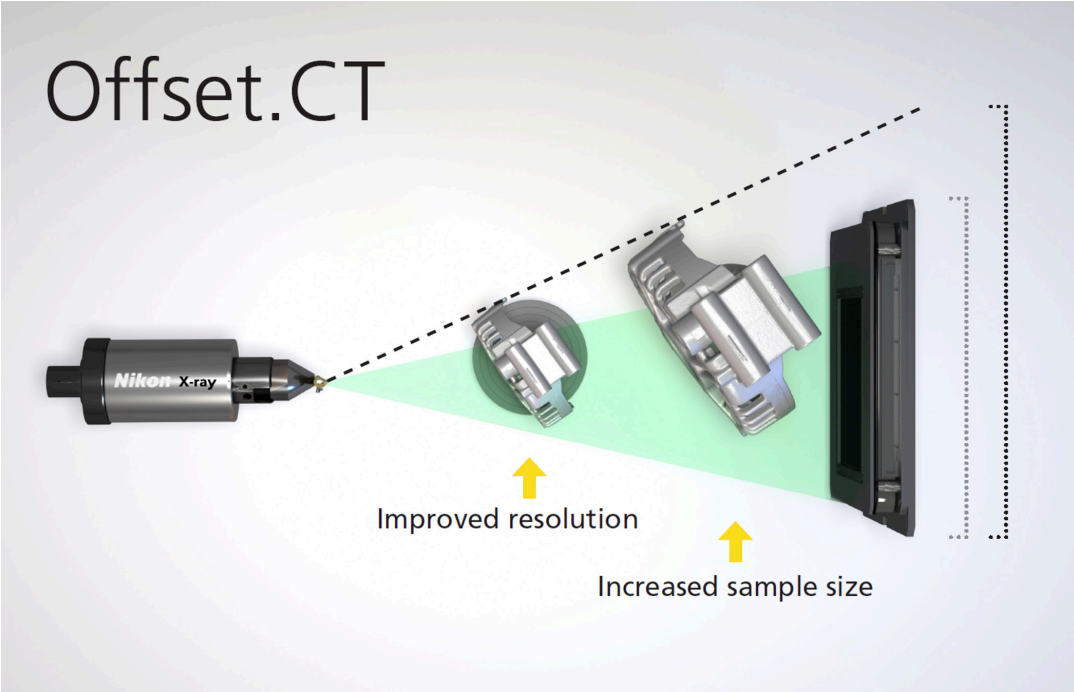
Enhanced X-ray CT inspection of automotive components with Offset.CT



OFFSET.CT

X-ray computed tomography (CT) scanning has become widely adopted in the automotive industry as an integral non-destructive testing (NDT) method for the inspection of key functional components. X-ray CT allows samples to be scanned without physical sectioning, to inspect, analyse and measure both internal and external features. Increased commercial emphasis on sustainable transport solutions and electric vehicle production has seen particular focus on the inspection of larger and more complex parts, through research, development and production phases. A significant challenge with larger sample inspection with X-ray CT is being able to inspect the whole part while maintaining high resolution and efficient cycle times. The advanced Offset.CT module, in combination with Nikon's other leading innovations, offers a unique solution for automotive manufacturers to maximise resolution and scan speed in large component inspection.

WHAT IS OFFSET.CT?

In a traditional CT scan, the sample being scanned must remain in the field-of-view during the entire rotation, in order to reconstruct the full sample in 3D. Conventionally, the detector must be larger than the component being scanned. Nikon's Offset.CT module allows the sample to rotate out of the field-of-view during scanning, while still being able to reconstruct the full sample in 3D. This means only around half of the sample must be within the field-of-view at any one time during rotation, allowing samples wider

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than the detector to be scanned, affording significant advantages for the inspection of components with larger or unsymmetrical aspect ratios.

When performing Offset.CT in Nikon X-ray CT systems, users have the option of acquiring either single-offset or dual-offset CT. Single-offset CT offsets the sample to one side of the detector in a single scan, reconstructing the full 3D sample from just one set of projection images, maximising cycle times. Dual-offset CT allows the user to collect two sets of projection images, one on each side of the detector that are combined into a single dataset, increasing the number of projection angles and subsequently the signal-to-noise ratio. Single-offset CT is the most common application, providing excellent image quality in minimal cycle time, where dual-offset CT can be applied in preliminary or investigative scans of components with complex geometry, where more data collection can be useful for inspection of subtle detail.

BENEFITS OF OFFSET.CT

Offset.CT allows significant benefits for automotive component inspection. Firstly, samples with large diameters, even those wider than the detector field-of-view, can be scanned in one pass to maximise throughput. Additionally, samples can be magnified to a much greater extent onto the detector by bringing the sample closer to the X-ray source; increasing the geometric magnification of the sample allows significantly higher resolution scan data. Where sample size is the limiting factor for resolution, Offset.CT allows significant enhancement in resolution capability.

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INSPECTING LARGER COMPONENTS WITH A SINGLE SCAN

A particular use case for Offset.CT is evidenced in battery module inspection, where individual battery cells requiring high resolution inspection are encapsulated in a much larger protective casing. Offset.CT can be utilised to scan the whole diameter of a large battery module in high resolution, rather than being limited to a smaller area at lower resolution. Throughput and analysis capabilities are significantly increased by performing multiple inspection tasks on a single Offset.CT scan, as opposed to having to perform multiple region-of-interest scans with standard CT.

As shown in Figure 1, Offset.CT data acquired with Nikon's Rotating.Target X-ray source technology achieves high-resolution and excellent image contrast, even with the extended diameter of a large battery module. A single, high-resolution dataset can be used to perform critical inspection tasks, being able to visualise misalignment of battery cells, measure small distances between materials, identify individual connections, analyse welding defects, perform void analysis and much more. The extended reconstructed volume from a single Offset.CT scan allows users to follow architecture and connections through the entire depth of the sample, an important analysis tool not possible with a single standard CT scan of the same sample.

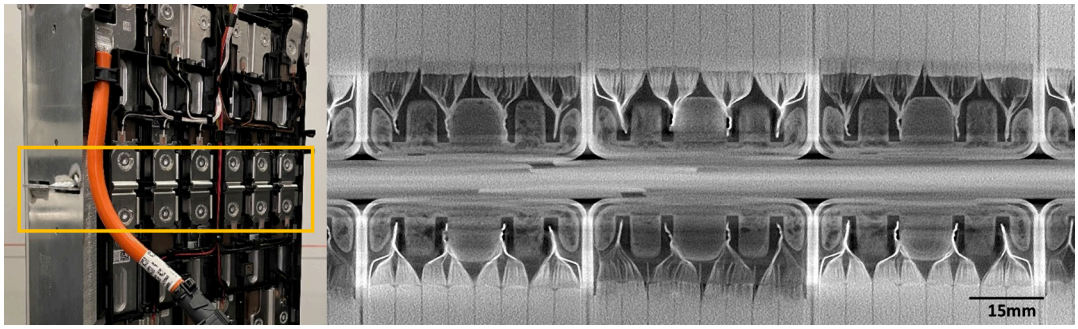
ACHIEVING HIGHER RESOLUTION SCANS WITHOUT SYSTEM MODIFICATION

With Offset.CT, no system modification is required, negating the requirement to upgrade to a larger detector, a detector with smaller pixel size, or even hardware modifications to move the detector panel. Detectors with smaller pixels provide higher resolution scan data, but it is important to consider that smaller pixels detect less flux, and these detectors are typically built with a thinner scintillator (the material used to detect X-rays), resulting in overall reduced sensitivity. Rather than having to change detector panels to improve resolution, Offset.CT enables users the benefit of using a high sensitivity detector, while additionally gaining the significant resolution advantages desired. In addition, Offset.CT provides the flexibility to choose the scan mode when required, for a panoramic view utilised for the specific application, improving the versatility of the system for a fraction of the cost.

HOW TO IMPROVE SCAN SPEED WITHOUT COMPROMISING RESOLUTION

A common trade-off that users face with CT acquisition is that improving scan speed typically sacrifices resolution. Scan speed improvements can be realised by detecting more X-ray flux in a

Figure 1



Offset.CT scan of the full diameter of an assembled battery module, scanned with the 450 kV microfocus Rotating. Target X-ray source, visualising a cross-section of individual battery cells and the connections leading to the busbar. Lower density separation material with voiding is visible.

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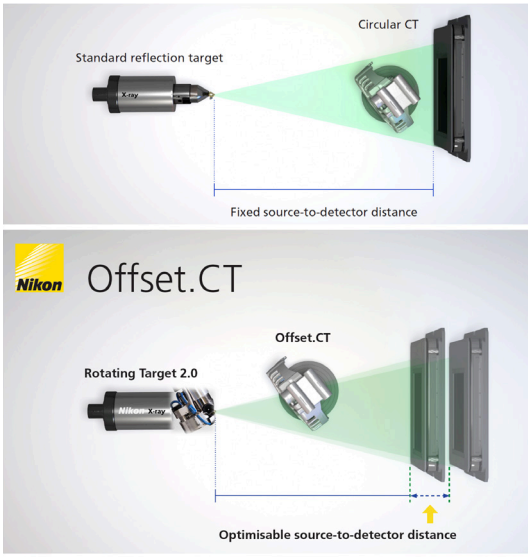

shorter time, either by increasing the power from the X-ray source, increasing the pixel size of the detector, or shortening the distance between source and detector; all of these options decrease image resolution. When more power is generated from the X-ray source, then typically the focal spot size (the area from which X-rays are produced) increases. The larger the focal spot, the worse the resolution.
To generate high X-ray flux without significant increase in the spot size, Nikon offers the unique Rotating.Target 2.0 X-ray source, achieving spots sizes three times smaller than a standard reflection target for the same power. The combination of Rotating. Target 2.0 and Offset.CT maximises scan speed for complex inspection tasks, as users can increase the X-ray flux to shorten cycle times, but with a smaller focal spot to achieve the required resolution. Built to both 225 kV and 450 kV specification with a continual maximum power of up to 450 Watts, Rotating.Target technology can be applied to a wide range of materials and components.

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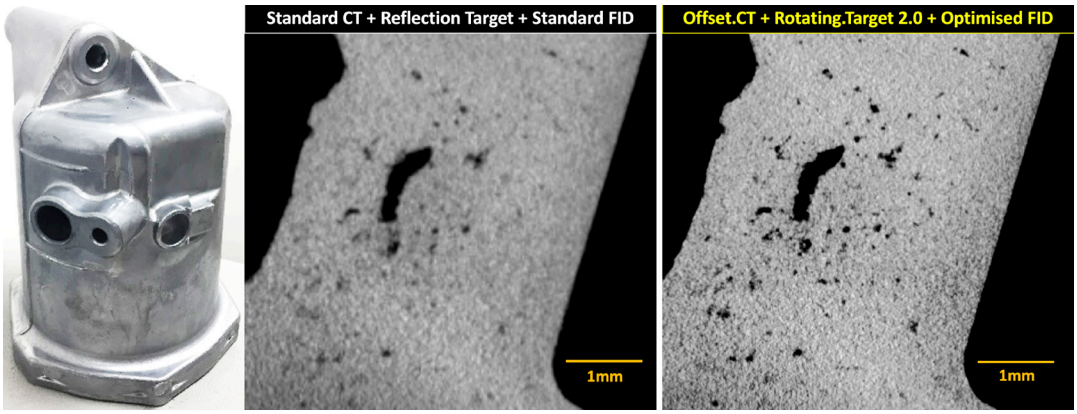
The Nikon XT H 225 ST 2x and Large Envelope Systems provide the flexibility to optimise the distance between source and detector, utilising intuitive motorised functionality. Combining this with Offset. CT and the unique Rotating.Target 2.0, Nikon offers an industry-unique solution for improving scan speed without compromising resolution. The significant increase in scan speed by reducing source-to-detector distance is coupled with the significant resolution advantages given by Offset.CT and Rotating.Target 2.0, meaning users achieve shorter scan times with improved resolution. As shown in Figure 2, Offset. CT can provide significant enhancements in CT data acquisition even for smaller components, evidenced by a cast metal sample. The three features used together in the same CT acquisition (Offset.CT, Rotating.Target 2.0 and optimised source-to-detector distance), a unique combination only offered by Nikon, results in 50% reduction in scan time while improving resolution by over 70%, in comparison to a standard CT scan with a static reflection target.

CONCLUSIONS

The Offset.CT software module benefits manufacturers within the automotive and many other industries by allowing larger components to be scanned and higher resolution to be achieved, without system modification. When combined with Nikon's other innovations in X-ray source technology and system capability, new possibilities in component inspection using X-ray CT can be realised, through enhanced resolution and cycle times. Components small and large benefit from Offset.CT, with the software module available in the entire range of Nikon X-ray CT systems from 180 kV through to 450 kV. The addition of Offset.CT vastly increases system versatility at a fraction of the cost of a new detector. All sample types can be scanned with Offset.CT, as it is integrated into Nikon's intuitive X-ray CT software package, with user-friendly workflows and industry-leading 3D data reconstruction times.

Figure 2



Offset.CT scan of a metal casting in combination with Rotating.Target 2.0 and optimised source-to-detector distance (right image), achieving a 50% reduction in scan time while enhancing resolution by 70%, compared to standard CT using a reflection target. Scan parameters chosen to produce similar dynamic range of grey values.

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