Strategies to improve the measuring time for industrial X-ray 3D Computed Tomography

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Abstract

The measuring time t_m is a limiting factor for the application of industrial X-ray 3D Computed Tomography (CT) as a test method for measuring tasks, especially in technical application areas with varying components [1]. The paper shows the influence of the number of projections n_p and the rotation technique on the image quality in dependence of the geometry and material of test objects for industrial X-ray 3D CT.

1. Introduction

There are an increasing number of applications for industrial X-ray 3D CT as a non-destructive test method for in-process quality assurance. Typical applications of industrial X-ray 3D CT are the inspection of turbine blades, carbon fiber reinforced components or metal and plastic castings. The relevant parameters for the measuring time t_m of industrial X-ray 3D CT applications are the rotation technique, the integration time t_i, the number of projections n_p and the reconstruction time t_r, which depends among others on the number of projections n_p (see Figure 1.1). The selection of a suitable integration time t_i is influenced by the measuring task, because the selection of a suitable integration time t_i depends on different factors such as the geometry and material of the test object, the X-ray source, the hardware filter (pre-filtration) or the gain. For example a higher X-ray power $P_{X\text{-}ray}$ allows the selection of a lower integration time t_i, with a simultaneous enlargement of the focal spot [1].

In the industrial X-ray 3D CT there are two different rotation techniques for the rotation of the test object: “Stop and Go Rotation Technique” and “Continuous Rotation Technique”. At the Continuous Rotation Technique the detector image acquisition is permanent while at the Stop and Go Rotation Technique the rotation axis triggers the detector. The rotation technique, the integration time and the number of projections n_p influence the image quality. This means that by reducing the measuring time t_m a lower image quality is expected [2].

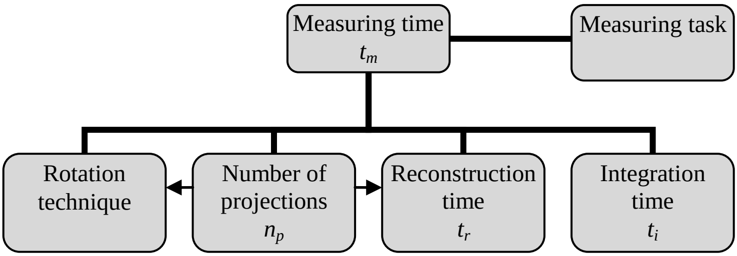

Figure 1.1: Composition of the measuring time for industrial X-ray 3D CT

2. Experimental Setup and Data evaluation

The influence on the image quality will be determined by performing CT scans, while varying the number of projections n_p, the rotation technique and the test objects. The experiment was carried out using a CARL ZEISS INDUSTRIAL METROLOGY Metrotom 800 scanner. The reconstruction was done using the software Metrotom OS 2.4 provided by CARL ZEISS INDUSTRIAL METROLOGY. As test objects, an aluminium square shaft and a cylinder with circle segments made of polycarbonate were used. The test objects were positioned vertically, and were not repositioned during the individual runs of the experiment.

For determination of the surface, the inspection software VG Studio Max 2.1 (VOLUME GRAPHICS) was used. The segmentation of the air and the material of the test object was conducted manually by specifying the test object on the peak with material.

3. Results and discussion

The result of the scans of the aluminium square shaft and the applied scanning parameters are shown in Figure 3.1. Due to the small number of projections n_p, especially at 36 and 72 projections, the Nyquist Sampling Theorem is not fulfilled, which results in aliasing artefacts in the reconstructed data. For some use cases, like the reconstruction of Printed Circuit Boards, the selection of less projections n_p could be sufficient.

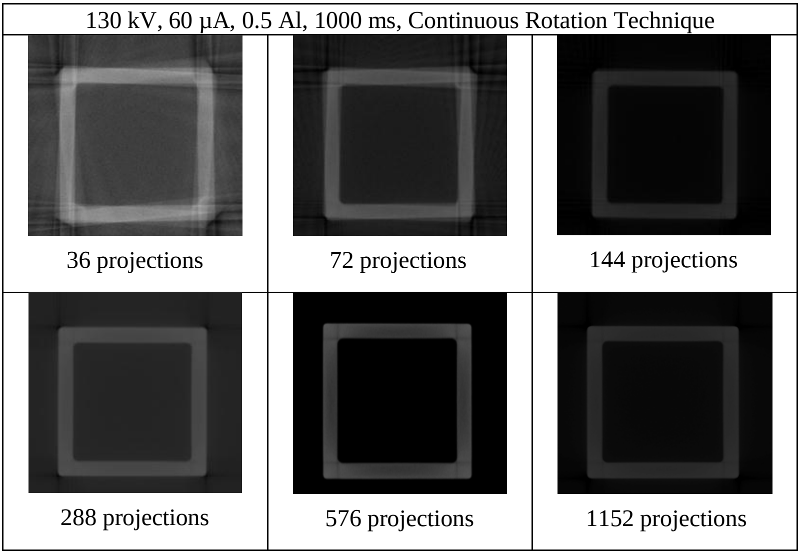

Figure 3.1: Reconstructed square shafts (VG Studio Max 2.1, VOLUME GRAPHICS)

In Figure 3.2 the contrast k depending on the number of projections n_p and the rotation technique is shown. In principle, the higher the number of projections n_p, the higher is the contrast k. Once the Nyquist Sampling Theorem is fulfilled, the contrast k is minimally increasing. This increase of contrast k is not in proportion to the measuring time t_m, which means, that the fulfillment of the Nyquist Sampling Theorem is in most applications sufficient.

The comparison between the different rotation techniques shows no significant difference in contrast k, despite significantly longer measuring time t_m. Thus in most use cases the Continuous Rotation Technique could be applied without a loss of image quality, while shortening the measuring time t_m. A comparison of polycarbonate and aluminium as well as axis and rotational symmetric test objects shows no difference between the results regarding the achieved contrast k.

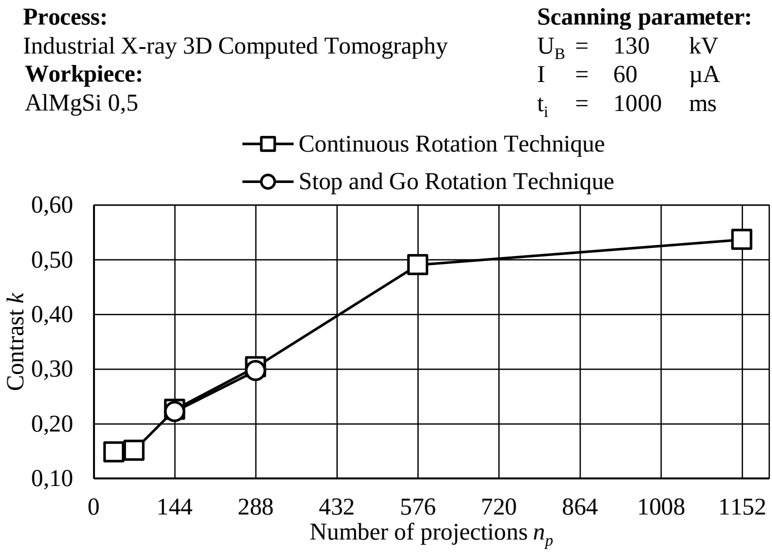

Figure 2.2: Contrast k depending on number of projections n_p and rotation technique

4. Conclusion

An essential criterion for the application of a measurement method is the measuring time t_m. This paper shows optimization possibilities regarding the measuring time t_m, particularly through the selection of a suitable number of projections n_p and the rotation technique. Compared to a measurement with the Stop and Go Rotation Technique, the measuring time t_m can be significantly shortened by application of the Continuous Rotation Technique without loss of image quality. Further research will consider the integration time t_i to optimize the measuring time t_m.

References:

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