Scanning Parameter Optimization for Inspection of Welding Defects in X-ray Linear Laminography

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Abstract
The x-ray imaging is one of the important non-destructive testing methods in the inspection of welding defect. The defect of welding joint can cause severe failure of the products, so the inspection of welding area is an essential issue in various industrial fields. We have studied the x-ray linear laminography system to imaging the welding defect. We investigated the effects of focal spot size and step interval on reconstructed images. The larger focal spot decreases the spatial resolution and smaller step interval reduces the noise of the image. Those parameters should be determined with considering of scanning time of welding sample.

Keywords: Laminography, Welding defect, Welding inspection

1 Introduction

Metal welding has been used for various applications, and they are located in even severe environments, such as sudden temperature changes. Small voids or space can cause deformation of welding joints and this phenomenon induces failure of entire products. Therefore the imaging of internal structure of metal welding region is an important issue in the industrial fields. The x-ray radiography is one of the Non-destructive testing methods for inspection of welding defect [1-2]. As figure 1 is shown, however, the micron-size defect can not be detected due to lack of contrast in the image. The conventional x-ray computed tomography can image those defects by rotating a part of welding samples. However, the extended area and micron-size defects are obstacles to inspecting whole welding region in short scanning time. We have proposed the x-ray linear laminography inspection system to inspect the welding region. To design the system, various parameters, which are including the source-detector distance (SDD), source-axis distance (SAD), focal spot size, detector pixel size, additive noise, etc. should be determined to generate a high quality image in short scanning time. We decided the detector pixel size and rough geometrical information through previous Monte-Carlo simulation studies. In this study, we investigated the effect of the focal spot and the step interval to tune the suitable scanning parameter.

Figure 1: The comparison between the radiograph (left) and the slice of reconstructed image (right)

2 Methods

The x-ray linear laminography system consists of a micro-focus x-ray source, a complementary metal-oxide-semiconductor (CMOS)-based image sensor array with 75 μm pixel pitch, and an object handling system. The object is shifted at regular intervals in a parallel direction to the long side of the detector array. While the scanning object is translated in a horizontal direction by the object handling system, the x-ray source, and the detector are stationary. In this study, the projections were obtained in a step-and-shoot mode. The source to object distance was 3 cm and the magnification factor was set by 4.8. For the reconstruction, the filtered backprojection algorithm [3] was for our system. According to the proposed scanning geometry, backprojection step was modified into the linear trajectory from the circular trajectory.

The focal spot of the x-ray tube defines the spatial resolution of the x-ray image [4]. Many x-ray sources have both small and large focal spot size depending on tube power, which is the product of current and voltage. The Small focal spot furthers more detailed imaging, but we have to choose between loss of voltage and current. In this study, we fixed the voltage
with 70 kVp which is enough to penetrate the welding region and adjusted the electric current to change the focal spot. The focal spot sizes were varied from 10 um to 70 um.

The step interval is also an important parameter to design the system because it determines the scanning time and image quality. The step interval should be decided in order to reduce the scanning time while maintaining image quality. The field-of-view was set to 14.5 mm and the step intervals were set to 0.2 mm, 0.25 mm, 0.3 mm, and 0.5 mm.

3 Result

The reconstructed slice images of the welding sample according to different focal spot size are shown in figure 1. As the size of the focal spot is larger, the spatial resolution is reduced. In figure 1(a) and figure 1(b), the voids are clearly seen. In figure 1(d), some of the small voids are cannot distinguish from the background. The reconstructed images with different step intervals are shown in figure 2. In theoretically, smaller step interval case has the chance to get number of projections, so the image is less noiser than wider step interval case. In the case with intervals of 0.2 mm and 0.25 mm, they have comparable image quality and the case with the interval of 0.5 mm is the noisiest image among the result in figure 2.

![Figure 1: Reconstruction image according to different focal spot size. (a) 10 um, (b) 20 um, (c) 40 um, and (d) 70 um.](image1)

![Figure 2: Reconstruction image according to different step interval. (a) 0.2mm, (b) 0.25mm, (c) 0.3mm, and (d) 0.5mm.](image2)

4 Discussion and Conclusion

In this paper, we investigated the parameter optimization for the imaging of welding defects in the x-ray linear laminography system. To validate the effect of focal spot size and the step interval, those parameters were varied and reconstruction parameters were not changed. The focal spot size of 10 um and 20 um are comparable in spatial resolution, so the choice of size of 20 um offers the chance to reduce exposure time per one projection by increasing electronic current.

Fast inspection of welding defects is an important issue in industrial mass production. As the scanning time per one projection decreases to reduce total scanning time, the percentage of Poisson noise increases because the number of photons which detected in the image receptor also decreases. By using of a suitable de-noising method, the image quality can be improved. Noise reduction in projection domain and image domain will be studied for the future study.

References


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