Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 88 (2017) 123 – 127

Physics Procedia

8th International Topical Meeting on Neutron Radiography, Beijing, China, 4-8 September 2016

The early stage of neutron tomography for cultural heritage study in Thailand

S.Khaweerat[a]*, W. Ratanatongchai[a], S.Wonglee[a], B. Schillinger[b]

[a]Thailand Institute of Nuclear Technology (Public Organization), 16 Vibhavadi Rangsit Rd., Chatuchak, Bangkok 10900, Thailand
[b]Heinz Maier-Leibnitz Zentrum (FRM II), Technische Universitaet Muenchen, Germany

Abstract

In parallel to the upgrade of neutron imaging facility at TRR-1/M1 since 2015, the practice on image processing software has led to implementation of neutron tomography (NT). The current setup provides a thermal neutron flux of 1.08×10^{6} $cm^{-2}sec^{-1}$ at the exposure position. In general, the sample was fixed on a plate at the top of rotary stage controlled by Labview 2009 Version 9.0.1. The incremental step can be adjusted from 0.45 to 7.2 degree. A 16 bit CCD camera assembled with a Nikkor 50 mm f/1.2 lens was used to record light from ^{6}LiF/ZnS (green) neutron converter screen. The exposure time for each shot was 60 seconds, resulting in the acquisition time of approximately three hours for completely turning the sample around. Afterwards, the batch of two dimensional neutron images of the sample was read into the reconstruction and visualization software Octopus reconstruction 8.8 and Octopus visualization 2.0, respectively. The results revealed that the system alignment is important. Maintaining the stability of heavy sample at every particular angle of rotation is important. Previous alignment showed instability of the supporting plane while tilting the sample. This study showed that the sample stage should be replaced. Even though the NT is a lengthy process and involves large data processing, it offers an opportunity to better understand features of an object in more details than with neutron radiography. The digital NT also allows us to separate inner features that appear superpositioned in radiography by cross-sectioning the 3D data set of an object without destruction. As a result, NT is a significant tool for revealing hidden information included in the inner structure of cultural heritage objects, providing great benefits in archaeological study, conservation process and authenticity investigating.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of ITMNR-8

Keywords: neutron tomography; research reactor utilization; TRR-1/M1, cultural heritage

* Corresponding author. Tel.: +662 401 9889 ext. 5924; fax: +0-000-000-0000 .
E-mail address: sasiphank@tint.or.th

1875-3892 © 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of ITMNR-8
doi:10.1016/j.phpro.2017.06.016

1. Introduction

The only one reactor-based neutron imaging (NI) facility in Thailand is currently upgrading. The NI facility located at Thai Research Reactor-1/Modification 1 (TRR-1/M1) has been used for more than 20 years. During the past few years, the technique has been dramatically improved since the IAEA Coordinated Research Project (CRP-F11018) titled "Application of Two and Three Dimensional Neutron Imaging with focus on Cultural Heritage Research" was initiated and Thailand is among the participating countries. In order to preserve the original characters of cultural heritage for our future generations, it is significant to perform all investigations on the objects of interest non-invasively. NI is a promising tool for implementing the requirement which has been recently applied in industry and material studies mentioned elsewhere (IAEA, 2008). It contributes to addressing archaeological questions in many countries; for instance, Switzerland (Deschler-Erb, Lehmann, Pernet, Vontobel, & Hartmann, 2004; Lehmann & Mannes, 2012; Lehmann, Vontobel, Deschler-Erb, & Soares, 2005), United States (Andreani, Gorini, & Materna, 2009), Italy (Salvemini et al., 2013) and Thailand (Khaweerat, Ratanatongchai, & Channuie, 2015; Khaweerat et al., 2015).

In Thailand as a Buddhism country, a variety of dedicating objects including Buddha sculptures have been continuously produced and distributed throughout the country for more than two millennia. The materials and styles of Buddha sculptures have changed over time and place. At present, the mix-up of original and replica sculptures is difficult to distinguish. Consequently, the combination of testing including NI, X-ray radiography (XR), instrumental neutron activation analysis (INAA) and X-ray fluorescence (XRF) were used for differentiating the sculptures (Khaweerat et al., 2015; Khaweerat et al., 2015). Besides, the outcomes provide significant evidences for determining provenances, manufacturing technology and traditional beliefs that imply authenticity of particular sculptures. In addition, the inner structural profiles can be taken into account for appropriate conservation methodology.

Even though two dimensional NI of several objects has been conducted routinely at TRR-1/M1, the complexity of the samples and the quality of the neutron beam lead to the difficulty in data analysis. As the NI facility was used since 1992, it needs additional development to achieve the now-current digital neutron tomography. Several difficulties including insufficient equipment and construction management resulted in the delay in the facility upgrade. Besides, we are currently facing other difficulties regarding low neutron flux at the NI facility as a result of UZrH fuel situation. The fuel remains very low in stock and it is unavailable for purchase as the vendor has shut down the fuel line production. Due to this fact reactor operating hours have decreased; however, the NI experiment is allowed to go on every other week.

The first draft of new collimator, shutter and shielding designs came out in early 2014 and the discussion went on with support from CRP-F11018 members, especially the co-author from, Technische Universität München - FRM II, Germany. We used the Monte Carlo code PHITS for radiation dose simulation of the current facility and the new design. The results showed that the radiation dose in the experimental hall can be reduced significantly when the upgrade is completed. It is also significant to determine the current beam characteristic including thermal neutron flux, cadmium ratio, beam distribution, and n/γ ratio. In parallel to the upgrade of the hardware, practicing on the 3D image processing software has been done. After less than three years since the upgrade plan began, the first 3D NI of Thai cultural heritage was achieved. Even though the images need further adjustment to obtain better resolution and contrast, it seems likely that the problem of overlapping structures of complicated samples can be solved. In addition, with the upgraded facility, it will be further possible to establish routine approaches for archaeological services and wide ranges of applications.

2. Methods

The NI experiment was composed of two parts which were data collection at NI beamline and data analysis using Octopus software.

In the early state, a compact set of a CCD camera (KAI4022) with a 200 µm PSI-Tritec ^{6}LiF/ZnS scintillation screen assembled in a light-tight-box was set up in the neutron beam at a distance of 100 cm from the reactor wall. In front of it was a prototype computer controlled rotary stage with object holder mounted on top of the stage (Fig.1). First set of sample were a small earthenware jar and a bronze Buddha sculpture with identical size of approximately

Download English Version:

https://daneshyari.com/en/article/5497196

Download Persian Version:

https://daneshyari.com/article/5497196

Daneshyari.com