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ScienceDirect

Physics Procedia 88 (2017) 13 – 18

Physics Procedia

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

Industrial application experiments on the neutron imaging instrument DINGO

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Abstract

The new neutron radiography / tomography / imaging instrument DINGO is operational since October 2014 to support the area of neutron imaging research at ANSTO. The instrument is designed for a diverse community in areas like defense, industrial, cultural heritage and archaeology applications. In the field of industrial application it provides a useful tool for studying cracking and defects in concrete or other structural material. Since being operational we gathered experience with industrial applications and commercial customers demanding beam time on DINGO. The instrument is a high flux facility with is 5.3×10^7 [n/(cm^{2}s)] (confirmed by gold foil activation) for an L/D of approximately 500 at HB-2. A special feature of DINGO is the in-pile collimator position in front of the main shutter at HB-2. The collimator offers two pinholes with a possible L/D of 500 and 1000. A secondary collimator separates the two beams by blocking one and positions another aperture for the other beam. The neutron beam size can be adjusted to the sample size from 50×50 mm^2 to 200×200 mm^2 with a resulting pixel size from 27 µm to ~100 µm. The whole instrument operates in two different positions, one for high resolution and one for high speed. We would like to present our first experience with commercial customers, scientific proposals with industrial applications and how to be customer ready.

Peer-review under responsibility of the organizing committee of ITMNR-8

Keywords: neutron tomography; non-invasive technique; archaeometallurgy

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Peer-review under responsibility of the organizing committee of ITMNR-8
doi:10.1016/j.phpro.2017.06.001

1. Introduction

Research facilities like ANSTO providing large-scale infrastructure facing at present time a transition from pure fundamental research to a more holistic approach serving a large variety of applied science disciplines and more commercial or industrial research. Neutron radiography and tomography station at other facilities like PSI, FRM 2, HZB and NIST have shown a high impact in industrial and commercial research [E. Lehman et al. 2011, B. Schillinger et al 2004, N. Kardilov et al 2011 and D.S. Hussey et al 2004].To address this strategic change a new cutting-edge neutron imaging instrument DINGO [U. Garbe et al 2015] was built from 2011 – 2014 to support the area of neutron imaging research. A major advantage of neutron radiation over X-rays and other imaging methods like MRI is high sensitive to hydrogen inside metals or ceramics or other light elements and higher penetration depth in combination with partially higher contrast between neighboring elements in the periodic table. Neutron radiation is used world-wide in quality control of explosive devices for mining, defense and industrial applications, for example to assess oil and water flow in sedimentary rock reservoirs, assessing water damage in aircraft components and the study of hydrogen embrittlement and cracking in zirconium-alloys. A large field of applications is utilizing neutron radiation instead of X-rays or both methods in combination. The user community varies from industrial or materials research, non-destructive testing, geology, archaeology and fundamental research. The facility is capable of providing two-dimensional "shadow" images of objects (radiography) and three-dimensional neutron tomography.

To attract industrial and commercial user we created a new working group at ACNS to target the specific needs of the community. The general message is that we do measurements and not experiments. In addition neutron imaging is part of ANSTOs industrial and commercial business portfolio not an isolated method to target industrial customers. We collaborate as whole ANSTO with all capabilities we can offer. We run a commercial group with scientist from all different departments and exchanging information and contacts. Within the group we understood that industry is demanding solutions. Finally neutron imaging might not be in the focus, but overall it leads to more customers due to the larger network. By showing all capabilities like the accelerator group, nuclear analysis, synchrotron and a strong materials engineering simulation group we are targeting a broader community and increase visibility for all of us.

2. Instrument Specifications

The instrument DINGO (figure 1) is fed by a thermal neutron beam defined by in-pile collimators positioned upstream of the main shutter. Two configurations are possible, by changing the collimator diameter D and the length L. The measurements presented in this paper were carried out with the high resolution configuration defined having producing a beam divergence of about 1mrad. In this way the neutron flux was 1.1×10^7 n/(cm^{2}s) measured by gold foil activation analysis. A second configuration, not used for the case studies, is optimized for high flux, with and measured flux of 5.33×10^7 n/(cm^{2}s). A set of pin holes, mounted on a selector wheel located 2.5 m downstream of the collimators, offers different apertures to reduce beam size down to 50×50 mm^2. No beam guide is used and the neutron beam is transported in helium filled flight tubes. The main components of the neutron imaging instrument are the sample table and the detector stage. The sample stage, designed for heavy load, can be adjusted over 4 degrees of freedom (three translations and the rotary stage for tomography). The remotely controlled xyz-translation table positions the sample in the field of view. To accommodate large samples the travel length of >500mm in x- and y-direction and 400mm in the z-direction is required. The table has a loading capacity of 500kg to position large samples and /or sample environment equipment accurately. In addition, three high precision rotation stages are available for neutron tomography with a maximum resolution of 0.001°. The largest rotation stage can take up to 200kg and the high accuracy rotation stage up to 40kg.