Jurnal Sains Nuklear Malaysia, 2014, 26(2): 9-13
ISSN: 2232-0946

HEEL EFFECT: DOSE MAPPING AND PROFILING FOR MOBILE C-ARM FLUOROSCOPY UNIT TOSHIBA SXT-1000A

Husaini Salleh[1], Supian Samat[2], Mohd Khalid Matori[1], Muhammad Jamal Md Isa[1], Mohd Ramli Arshad[1], Shahrul Azlan Azizan[1], Mohd Firdaus Abdul Rahman[1] and Md Khairusalih Md Zin[1]

[1]AgensiNuklear Malaysia, Bangi, 43000 Kajang, Selangor, Malaysia
[2]Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
Correspondence author: husaini@nm.gov.my

ABSTRACT

Heel Effect is the well known phenomena in x-ray production. It contributes the effect to image formation and as well as scattered radiation. But there is paucity in the study related to heel effect. This study is for mapping and profiling the dose on the surface of water phantom by using mobile C-arm unit Toshiba SXT-1000A. Based on the result the dose profile is increasing up to at least about 57% from anode to cathode bound of the irradiated area. This result and information can be used as a guide to manipulate this phenomenon for better image quality and radiation safety for this specific and dedicated fluoroscopy unit.

Keywords: Heel effect, dose mapping, film, fluoroscopy, profiling, x-ray

INTRODUCTION

The heel effect is a well-known phenomenon, but there is a paucity of reports demonstrating its exploitation in clinical departments for optimizing images (Mearon and Brennan, 2006) as well as scattered radiation and its risk to patient and staff. The heel effect is due to attenuation at the anode, causing less x-rays to be produced at the anode side. The main contributor to the heel effect is the anode angle which is typically about 15 degree (Mandell, 2013). Figure 1 shows how the film can be affected by heel effect and give the differences in optical densitometry.

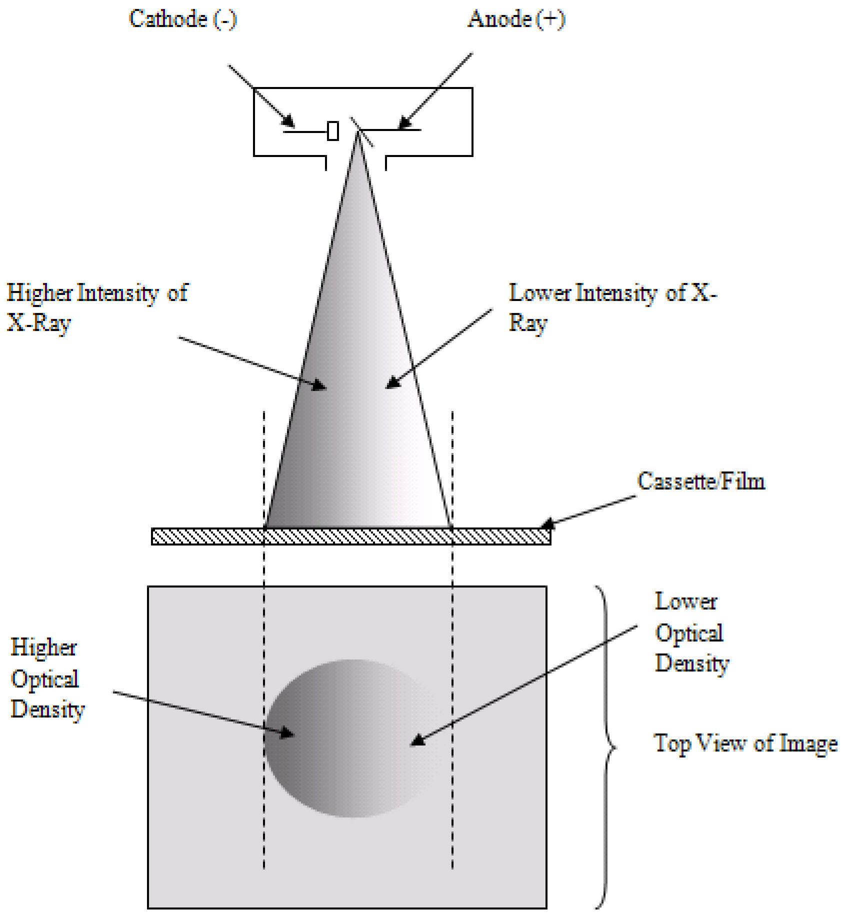

Figure 1: Typical Heel Effect that occurs while producing x-rays using the circular collimator of mobile C-arm unit. The higher intensity of x-ray makes the higher optical density on film

MATERIALS AND METHODS

This study was carried out using the Medical Physics Group's facilities at Malaysian Nuclear Agency. There were several main instruments used in this study:

i) mobile C-Arm fluoroscopy, model Toshiba SXT-1000A with power rating of 110 kV, 16 mA and 1.76 kW. The normal size of image intensifier (II) is 23 cm
ii) water phantom made of perspex casing with sizes of (20 x 30 x 30 cm)
iii) solid state detector (Unfors Xi @ RaySafe multimeter). The room temperature during the measurement ranged within 22ºC to 24ºC, while pressure was between 99.8 kPa to 100.5 kPa
iv) conventional film/cassette
v) densitometer

There are 2 types of dose profiles study that have been done in order to find out the better way for profiling. First is using the film (with and without the screen) and the second one is using solid state detector. The distance of focus to the surface of water phantom is 62.0 cm. Both the film and solid state detector are placed on top surface of the water phantom. For this set up, the diameter of circular beam field size on water phantom is about 13.7 cm.

Using Film

The films (with and without screen) were exposed to x-ray with radiographic and fluoroscopic mode. For radiographic mode (film with screen) the parameters used are 50 kV and 1 mA while for fluoroscopic mode (film without screen) are using 77 kV, 1.7 mA and 5 seconds exposure. This fluoroscopic mode runs on auto brightness control (ABC) and the use of film without screen is suitable for this ABC comparable to the use of film with screen that will push the kV and mA to the higher values. The optical density is measured along the anode-cathode with 1.0 cm interval.

Using Solid State Detector

The RaySafe detector was exposed to x-ray along anode-cathode for radiographic mode and along anode-cathode and left-right axis with 1.0 cm interval with fluoroscopic mode. The use of radiographic and fluoroscopic mode is just for comparison and to get the rough idea of the most suitable mode for profiling. For radiographic mode the parameter used are 78 kV and 1 mAs while for fluoroscopic mode 77 kV, 1.7 mA and 5 seconds are used.

RESULTS AND DISCUSSION

Based on the result, this work affirms that Heel Effects gives rise to more dose to cathode bound of the irradiated area on the water phantom as shown in Figure 2, 3 and 4. The use of film result is showed in Figure 2 and the use of solid state detector is presented in Figure 3 and 4.

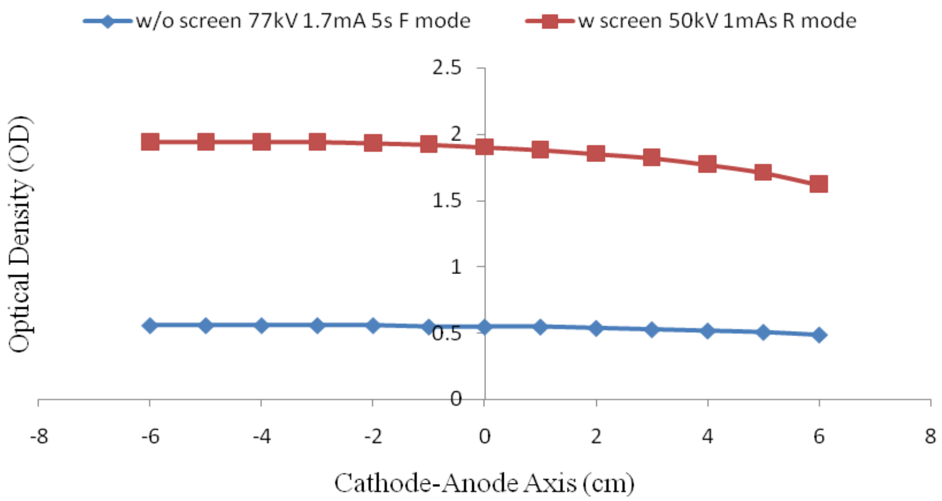

Figure 2: The measured optical density of beam profile shows Heel Effect on the exposed film. It is increasing dose on the cathode bound compared to anode bound. The optical density seemed to be saturated at cathode bound by using 50 kV, 1 mAs (radiographic mode-with screen). Test using non-screen film with 77 kV, 1.7 mA, 5 seconds exposure (fluoroscopic mode) giving minimum 0.47 OD and maximum 0.56 OD

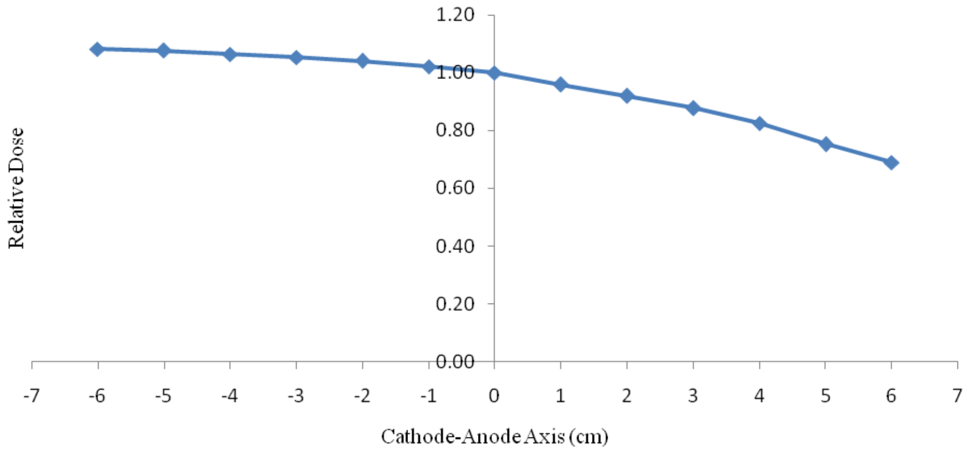

Figure 3: The measured dose of beam profile shows Heel Effect on the surface of water phantom. The increasing dose on the cathode bound by about +8% and -31% for anode bound relative to the dose at the central position. Negative symbol is cathode bound whereas positive is anode bound. (78 kV, 16 mA, 1 mAs-radiographic mode). Cathode edge ~56.5% more dose than anode egde

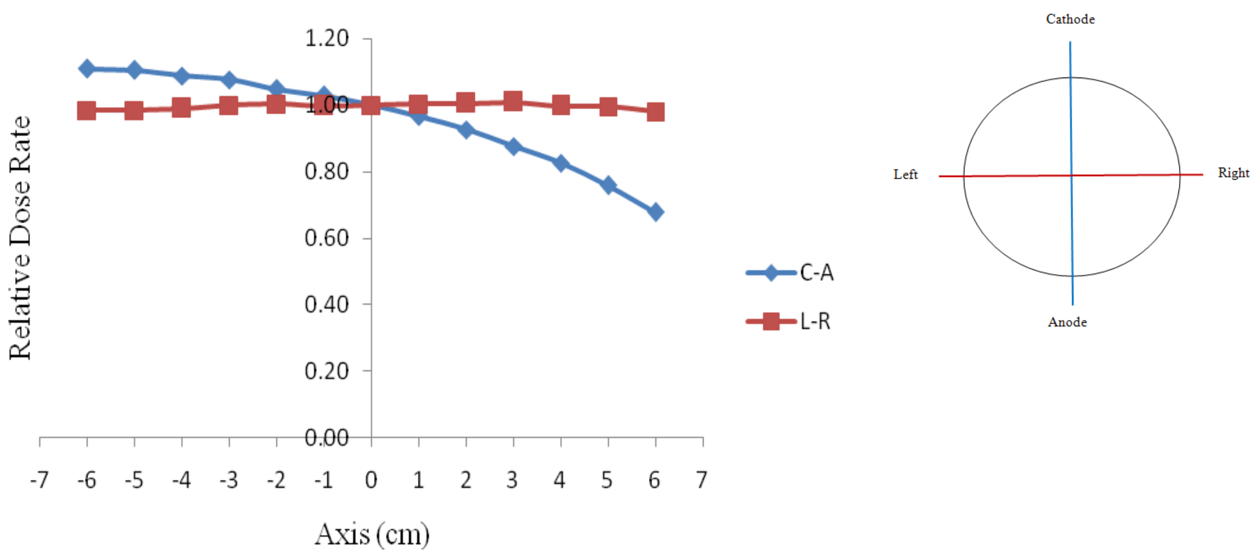

Figure 4: The relative dose rate of beam profile shows the increasing dose on the cathode bound by about +10.9% and decreasing -32.1% for anode bound relative to the dose at the central position. Cathode edge ~63% more dose than anode edge. For left-right axis the average relative dose rate is 1.0 ± 0.9 %. (77 kV, 1.7 mA, 5 seconds, fluoroscopic mode)

Film without screen is less sensitive compared to film with screen. Even though the parameter used is lower, the film with screen can give more optical density than the film without screen. The only problem for film with screen is the saturated area of optical density for higher exposures.

By using solid state detector, the dose and the dose rate can be measured and plotted as in Figure 3 and 4. The dose for radiographic mode while dose rate for fluoroscopic mode. The result based on dose reading is clearer than optical density reading.

The use of film, either with screen or without screen for profiling is little bit difficult due to various factor that can affected the result such as the performance of film, chemical etc. To obtain the better result, we have to study on film characteristic curve to make sure that the exposures made are within the sensitive gradient curve area. In this area, any small changes of relative exposure will give big changes in optical density measured.

Solid state detector is more convenient to use for dose profiling of irradiated area. The result can be obtained immediately but need to be done with many repeated exposures. The use of TLD or OSL can overcome these repeated exposures but we need to spend time for analyzing to get the dose reading.

CONCLUSIONS

Based on the result, it shows that heel effect for this Toshiba SXT-1000A giving more doses to cathode bound at least ~57 % of the anode bound of the beam edge. This result and information can be used to manipulate this phenomena for better image quality and radiation safety especially in scattered radiation risk (Salleh, 2014) for this specific and dedicated fluoroscopy unit.

ACKNOWLEDGEMENTS

Thanks a lot to all who involve in this study directly and indirectly. To all of the Medical Physics Group staff and management of Malaysian Nuclear Agency that give the fully support to every R & D activity.

REFERENCES

Mandell, J. (2013). 978-1-107-67968-9 - Core Radiology: A Visual Approach to Diagnostic Imaging. Cambridge University Press, United Kingdom.

Mearon, T. and Brennan, P.C. (2006). Anode Heel Effects In Thoracic Radiology: A Visual Grading Analysis", Proc. SPIE 6142, *Medical Imaging: Physics of Medical Imaging*, 61423D. doi: 10.1117/12.641623.

Salleh, H., Samat, S.B., Matori, M.K. and Isa, M.J.M. (2014). Anode-Cathode Position: How It Influences The Radiation Risk To Staff, Trans Tech Publication, Switzerland in *Advanced Material Research,*1087: 405-414.